

6-2

Exponents and Multiplication

 Check Skills You'll Need

- 1. Vocabulary Review**
What is the *base* of the exponential expression x^y ?

Simplify each expression.

2. $(-1)^4$ 3. $(-3)^2$
4. -3^2 5. -1^4

GO for Help
Lesson 1-2

What You'll Learn

To multiply powers with the same base

Why Learn This?

Computer programmers often use exponents with base 2, base 8, or base 16 to express numbers. To perform calculations within these number systems, you need to know how to multiply with exponents.



You can write the expression $3^2 \cdot 3^4$ using a single exponent.

$$3^2 \cdot 3^4 = (3 \cdot 3)(3 \cdot 3 \cdot 3 \cdot 3) = 3^6$$

The two factors of 3 together with four factors of 3 give a total of six factors of 3. Notice that the exponent 6 is equal to the sum of the exponents 2 and 4.

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Vocabulary Tip

The word *power* can be used in two ways. The expression a^n is a power. You can also read a^n as "a to the n th power."

KEY CONCEPTS Multiplying Powers With the Same Base

To multiply numbers or variables with the same base, add the exponents.

Arithmetic

$$3^2 \cdot 3^7 = 3^{(2+7)} = 3^9$$

Algebra

$$a^m \cdot a^n = a^{(m+n)}$$

EXAMPLE Multiplying Powers

- 1** Write the expression $(-2)^3 \cdot (-2)^5$ using a single exponent.

$$\begin{aligned} (-2)^3 \cdot (-2)^5 &= (-2)^{(3+5)} && \leftarrow \text{Add the exponents.} \\ &= (-2)^8 && \leftarrow \text{Simplify the exponent.} \end{aligned}$$

Quick Check

1. Write each expression using a single exponent.

a. $6^2 \cdot 6^3$

b. $(-4) \cdot (-4)^7$

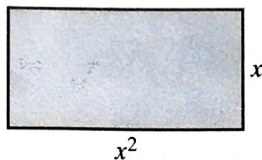
c. $3 \cdot 3^2 \cdot 3^3$

Vocabulary Tip

Terms raised to the second power are often referred to as *squared*, while terms to the third power are said to be *cubed*.

EXAMPLE Application: Geometry

- 2 **Multiple Choice** Find the area of the rectangle.



- (A) x^2 (B) x^3 (C) $2x^2$ (D) $2x^3$

Recall that the area of a rectangle is $A = \ell \cdot w$, where ℓ is the length and w is the width.

Let $\ell = x^2$ and $w = x$.

$$A = \ell \cdot w \quad \leftarrow \text{Write the area formula.}$$

$$A = x^2 \cdot x \quad \leftarrow \text{Substitute } x^2 \text{ for } \ell \text{ and } x \text{ for } w.$$

$$A = x^{(2+1)} \quad \leftarrow \text{Add the exponents.}$$

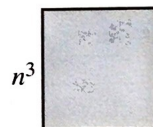
$$A = x^3 \quad \leftarrow \text{Simplify.}$$

The area of the rectangle is $A = x^3$.

The correct answer is choice B.

Quick Check

2. A square has a side length of n^3 . Find the area of the square.



EXAMPLE Using the Commutative Property

- 3 Simplify the expression $-3x^2 \cdot 5x^4$.

$$-3x^2 \cdot 5x^4 = -3 \cdot 5 \cdot x^2 \cdot x^4 \quad \leftarrow \text{Use the Commutative Property of Multiplication.}$$

$$= -15x^{(2+4)} \quad \leftarrow \text{Add the exponents of powers with the same base.}$$

$$= -15x^6 \quad \leftarrow \text{Simplify.}$$

Quick Check

3. Simplify each expression.

a. $2a^2 \cdot 3a$

b. $x^{10} \cdot x^3$

c. $-4y^5 \cdot -3y^5$

Calculator Tip

When using a calculator to evaluate expressions with exponents, be sure to use parentheses when needed.

Check Your Understanding

For Exercises 1 and 2, fill in the blank.

1. $(8)^3 \cdot (\square)^4 = 8^7$

2. $5^3 \cdot 5^{\square} = 5^6$

Write each expression using a single exponent.

3. $(-6)^2 \cdot (-6)^2$

4. $(-2)^8 \cdot (-2)^3$

5. $7^2 \cdot 7^8$

6. $4^5 \cdot 4^6$

7. **Error Analysis** A student simplified $5^2 \cdot 5^4$. His work is shown below. Explain the student's error.

$$5^2 \cdot 5^4 = 5 \cdot 5^{(2+4)} = 25^6$$

8. **Mental Math** Write a product of two powers that is equal to 3^6 .

Homework Exercises

For more exercises, see Extra Skills and Word Problems.

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For Exercises	See Example
9–16	1
17	2
22–33	3

Write each expression using a single exponent.

9. $y^3 \cdot y^5$

10. $m^{10} \cdot m^{100}$

11. $3.4^3 \cdot 3.4^{10}$

12. $12^5 \cdot 12^{50}$

13. $4.5^{10} \cdot 4.5^{10}$

14. $(-5)^5 \cdot (-5)$

15. $0.4^5 \cdot 0.4^{10}$

16. $x \cdot x^0$

17. **Earth Science** The Hudson River in New York is about 2^9 km long. The Columbia River in Oregon is 2^2 times longer. How long is the Columbia River? Write your answer with exponents.



18. **Guided Problem Solving** An architect is designing a deck. It will be $5x$ ft long and $2x$ ft wide. Write an expression for the area of the deck when it is completed.

- Use the area formula $A = \ell w$.
- Simplify the expression.

19. **Open-Ended** Give three different ways to write 4^{12} as the product of two powers.

20. **Writing in Math** Explain why you *cannot* write $5^3 \cdot 7^9$ as $(35)^{12}$.

21. Double the number 2^5 . Write your answer as a single exponent.

Write each expression using a single exponent.

22. $4^x \cdot 4^t$ 23. $3^m \cdot 3^n$ 24. $1.5^8 \cdot 1.5^t$
 25. $(-4)^x \cdot (-4)^y$ 26. $2^3 \cdot 2 \cdot 2^8$ 27. $a^5 \cdot a^4 \cdot a$
 28. $9^{12} \cdot 9^6 \cdot 9^3$ 29. $3^a \cdot 3^{2a} \cdot 3^{3a}$ 30. $xy \cdot x^2y^3$
 31. $c^2d \cdot cd^3$ 32. $x \cdot x^3 \cdot x^5$ 33. $3x^2 \cdot x^5 \cdot x$

34. **Geometry** The formula for the area of a square is $A = s^2$. What is the area of a square with sides that are $3x^2$ cm?

Use $<$, $>$, or $=$ to complete each statement.

35. 4^6 \blacksquare $4^3 \cdot 4^2$ 36. 36 \blacksquare $6^2 \cdot 6^2$ 37. 5^{16} \blacksquare $5^8 \cdot 5^2$

38. A milligram is 10^{-3} grams. A kilogram is 10^3 grams. How many milligrams are in a kilogram?

39. **Challenge** If $(h + h) \cdot (h \cdot h) = 16$, what is the value of h ?

Test Prep and Mixed Review

Practice

Multiple Choice

40. Look for a pattern in the table at the right. Based on the pattern in the table, what value of x makes the statement $4^{15} = 2^x$ true?

- (A) 15
 (B) 20
 (C) 30
 (D) 7.5

Powers of 4	Powers of 2
$4^2 = 16$	$2^4 = 16$
$4^3 = 64$	$2^6 = 64$
$4^4 = 256$	$2^8 = 256$
$4^5 = 1024$	$2^{10} = 1024$

41. On a typing test, Lana typed 900 words in 5 minutes. Sierra typed 980 words in 7 minutes. Which of the following statements is true?
 (F) Lana's average typing rate was 67 words per minute faster than Sierra's average rate.
 (G) Sierra's average typing rate was 80 words per minute faster than Lana's average rate.
 (H) Lana's average typing rate was 40 words per minute faster than Sierra's average rate.
 (J) Lana's average typing rate was the same as Sierra's average typing rate.

Find each unit rate.

42. \$75 for 15 books 43. 150 mi in 3.5 h 44. \$150 for 250 lb

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For Exercises	See Lesson
42-44	3-3