

 **5-Minute Check**

Over Lesson 7-1

Standardized Test Practice**6** What is the product $(-3x^2y^3z^2)(-17x^3z^4)$?

A. $20x^5y^3z^6$

B. $20x^6y^3z^8$

C. $51x^5y^3z^6$

D. $51x^6y^3z^8$

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Standardized Test Practice

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LESSON 7-2 Division Properties of Exponents

$$(x^8)(x^3) = x \cdot x \cdot x \cdot x \cdot x \cdot x \cdot x \cdot x \cdot x \cdot x \cdot x$$

$$= x^{11}$$

Key Concept Quotient of Powers



Words To divide two powers with the same base, subtract the exponents.

Symbols For any nonzero number a , and any integers m and p , $\frac{a^m}{a^p} = a^{m-p}$.

Examples $\frac{c^{11}}{c^8} = c^{11-8}$ or c^3 $\frac{r^5}{r^2} = r^{5-2} = r^3$

$$\frac{x^8}{x^3} = \frac{x \cdot x \cdot x \cdot x \cdot x \cdot x \cdot x \cdot x}{x \cdot x \cdot x} = x^5$$

LESSON 7-2 Division Properties of Exponents

EXAMPLE 1 Quotient of Powers

Simplify $\frac{x^7 y^{12}}{x^6 y^3}$. Assume that x and y are not equal to zero.

$$\begin{aligned} \frac{x^7 y^{12}}{x^6 y^3} &= \left(\frac{x^7}{x^6} \right) \left(\frac{y^{12}}{y^3} \right) \\ &= (x^{7-6})(y^{12-3}) \\ &= xy^9 \end{aligned}$$

Handwritten explanation for $\frac{y^3}{y^{12}}$:

$$\frac{y^3}{y^{12}} = \frac{y^{-9}}{1} = \frac{1}{y^9}$$

The diagram shows the cancellation of 9 y's from the numerator and denominator, leaving 3 y's in the numerator and 9 y's in the denominator, which results in y^{-9} .

Group powers that have the same base.

Quotient of Powers

Simplify.

EXAMPLE 1



Check Your Progress

Simplify $\frac{a^3b^9}{ab^2}$. Assume that a and b are not equal to zero.

A. a^4b^{11}

B. $\frac{b^7}{a^2}$

C. $a^3b^{\frac{9}{2}}$

D. a^2b^7

EXAMPLE 1

 **Check Your Progress**

Simplify $\frac{a^3b^9}{ab^2}$. Assume that a and b are not equal to zero.

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LESSON 7-2 Division Properties of Exponents

Key Concept Power of a Quotient

Words To find the power of a quotient, find the power of the numerator and the power of the denominator.

Symbols For any real numbers a and $b \neq 0$, and any integer m , $\left(\frac{a}{b}\right)^m = \frac{a^m}{b^m}$.

Examples $\left(\frac{3}{5}\right)^4 = \frac{3^4}{5^4}$ $\left(\frac{r}{t}\right)^5 = \frac{r^5}{t^5}$

EXAMPLE 2 Power of a Quotient

Simplify $\left(\frac{4c^3d^2}{5}\right)^3$.



EXAMPLE 2
 **Check Your Progress**

Simplify $\left(\frac{3m^3n^2}{4p^5q}\right)^3$. Assume that p and q are not equal to zero.

- A. $\frac{3m^9n^6}{4p^{15}q^3}$
- B. $\frac{27m^9n^6}{64p^{15}q^3}$
- C. $\frac{27m^6n^3}{64p^8q^4}$
- D. $\frac{6m^6n^5}{7p^{15}q}$

EXAMPLE 2

 **Check Your Progress**

Simplify $\left(\frac{3m^3n^2}{4p^5q}\right)^3$. Assume that p and q are not equal to zero.

A. $\frac{3m^9n^6}{4p^{15}q^3}$

B. $\frac{27m^9n^6}{64p^{15}q^3}$

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D. $\frac{6m^6n^5}{7p^{15}q}$

LESSON 7-2 Division Properties of Exponents

Key Concept Zero Exponent Property

Words Any nonzero number raised to the zero power is equal to 1.

Symbols For any nonzero number a , $a^0 = 1$.

Examples $15^0 = 1$ $\left(\frac{b}{c}\right)^0 = 1$ $\left(\frac{2}{7}\right)^0 = 1$

EXAMPLE 3**Zero Exponent**

A. Simplify $\left(\frac{12m^8n^7}{8m^5n^{10}}\right)^0$. Assume that m and n are not equal to zero.



EXAMPLE 3 Zero Exponent

B. Simplify $\frac{m^0 n^3}{n^2}$. Assume that m and n are not equal to zero.

$$\frac{y^3}{y^{12}} = \frac{y^{-9}}{1} = \frac{1}{y^9}$$

Handwritten diagram illustrating the simplification of $\frac{y^3}{y^{12}}$. The numerator is y^3 and the denominator is y^{12} . The result is shown as $\frac{y^{-9}}{1} = \frac{1}{y^9}$. A dashed box highlights the cancellation of 9 y 's from both numerator and denominator, leaving 3 y 's in the denominator. The final result $\frac{1}{y^9}$ is shown with a downward arrow pointing to the 9 in the denominator.

LESSON 7-2 Division Properties of Exponents

Key Concept Negative Exponent Property

Words For any nonzero number a and any integer n , a^{-n} is the reciprocal of a^n . Also, the reciprocal of a^{-n} is a^n .

Symbols For any nonzero number a and any integer n , $a^{-n} = \frac{1}{a^n}$.

Examples $2^{-4} = \frac{1}{2^4} = \frac{1}{16}$ $\frac{1}{j^{-4}} = j^4$

EXAMPLE 4 Negative Exponents

A. Simplify $\frac{x^{-4}y^9}{z^{-6}}$. Assume that no denominator is equal to zero.

$$\frac{x^{-4}y^9}{z^{-6}} = \frac{y^9z^6}{x^4}$$

Negative Exponent Property

Answer: $\frac{y^9z^6}{x^4}$

EXAMPLE 4 Negative Exponents

B. Simplify $\frac{75p^3q^{-5}}{15p^5q^{-4}r^{-8}}$. Assume that p , q and r are not equal to zero.

$$\frac{75p^3q^{-5}}{15p^5q^{-4}r^{-8}} = \left(\frac{75}{15}\right)\left(\frac{p^3}{p^5}\right)\left(\frac{q^{-5}}{q^{-4}}\right)\left(\frac{1}{r^{-8}}\right) \quad \text{Group powers with the same base.}$$

$$= 5(p^{3-5})(q^{-5-(-4)})(r^8) \quad \text{Quotient of Powers and Negative Exponent Property}$$

EXAMPLE 4 Negative Exponents

$$= 5p^{-2}q^{-1}r^8$$

Simplify.

$$= 5\left(\frac{1}{p^2}\right)\left(\frac{1}{q}\right)r^8$$

Negative Exponent Property

$$= \frac{5r^8}{p^2q}$$

Multiply.

Answer: $\frac{5r^8}{p^2q}$

EXAMPLE 4

 Check Your Progress

B. Simplify $\frac{36x^5y^8z^3}{9x^4y^2z^6}$. Assume that no denominator is equal to zero.

A. $\frac{xy^6z^3}{4}$

B. $\frac{27xy^6}{z^3}$

C. $\frac{4z^3}{xy^6}$

D. $\frac{4xy^6}{z^3}$

EXAMPLE 4



Check Your Progress

B. Simplify $\frac{36x^5y^8z^3}{9x^4y^2z^6}$. Assume that no denominator is equal to zero.

A. $\frac{xy^6z^3}{4}$

B. $\frac{27xy^6}{z^3}$

C. $\frac{4z^3}{xy^6}$

D. $\frac{4xy^6}{z^3}$

 Real-World Example 5

Apply Properties of Exponents

SAVINGS Darin has \$123,456 in his savings account. Tabo has \$156 in his savings account. Determine the order of magnitude of Darin's account and Tabo's account. How many orders of magnitude as great is Darin's account as Tabo's account?

Understand We need to find the order of magnitude of the amounts of money in each account. Then find the ratio of Darin's account to Tabo's account.

Plan Round each dollar amount to the nearest power of ten. Then find the ratio.

 Real-World Example 5

Apply Properties of Exponents

Solve

The amount in Darin's account is close to \$100,000. So, the order is 10^5 . The amount in Tabo's account is close to 100, so the order of magnitude is 10^2 .

The ratio of Darin's account to Tabo's account is $\frac{10^5}{10^2}$ or 10^3 .

Answer: So, Darin has about 1000 times as much as Tabo, or Darin has 3 orders of magnitude as much in his account as Tabo.

Check Your Understanding

 = Step-by-Step Solution  in on page R13.

Examples 1–4 Simplify each expression. Assume that no denominator equals zero.

1. $\frac{t^5 u^4}{t^2 u} \cdot t^3 u^3$

2. $\frac{a^6 b^4 c^{10}}{a^3 b^2 c}$

3. $\frac{m^6 r^5 p^3}{m^5 r^2 p^3} \cdot mr^3$

4. $\frac{b^4 c^6 f^8}{b^4 c^3 f^5}$

5. $\frac{g^8 h^2 m}{hg^7} \cdot ghm$

6. $\frac{r^4 t^7 v^2}{t^7 v^2}$

7. $\frac{x^3 y^2 z^6}{z^5 x^2 y} \cdot xyz$

8. $\frac{n^4 q^4 w^6}{q^2 n^3 w}$

9. $\left(\frac{2a^3 b^5}{3}\right)^2 \cdot \frac{4a^6 b^{10}}{9}$

10. $\frac{r^3 v^{-2}}{t^{-7}}$

11. $\left(\frac{2c^3 d^5}{5g^2}\right)^5 \cdot \frac{32c^{15} d^{25}}{3125g^{10}}$

12. $\left(-\frac{3xy^4 z^2}{x^3 yz^4}\right)^0$

13. $\left(\frac{3f^4 gh^4}{32f^3 g^4 h}\right)^0$

14. $\frac{4r^2 v^0 t^5}{2rt^3}$

15. $\frac{f^{-3} g^2}{h^{-4}} \cdot \frac{g^2 h^4}{f^3}$

16. $\frac{-8x^2 y^8 z^{-5}}{12x^4 y^{-7} z^7} \cdot \frac{-2y^{15}}{3x^2 z^{12}}$

17. $\frac{2a^2 b^{-7} c^{10}}{6a^{-3} b^2 c^{-3}} \cdot \frac{a^5 c^{13}}{3b^9}$

Example 5

18. **FINANCIAL LITERACY** The gross domestic product (GDP) for the United States in 2008 was \$14.204 trillion, and the GDP per person was \$47,580. Use order of magnitude to approximate the population of the United States in 2008.

$\textcircled{3} \cdot m^1 r^3$

Examples 1–4 Simplify each expression. Assume that no denominator equals zero.

$$19. \frac{m^4 p^2}{m^2 p} m^2 p$$

$$22. \frac{c^4 d^4 f^3}{c^2 d^4 f^3} c^2$$

$$25. \left(\frac{p^2 t^7}{10}\right)^3 \frac{p^6 t^2 1}{1000}$$

$$28. \left(\frac{3np^3}{7q^2}\right)^2 \frac{9n^2 p^6}{49q^4}$$

$$31. \left(\frac{5f^9 g^4 h^2}{fg^2 h^3}\right)^0 1$$

$$34. \frac{5c^2 d^5}{8cd^5 f^0} \frac{5c}{8}$$

$$37. \frac{k^4 m^3 p^2}{k^2 m^2} k^2 m p^2$$

$$40. \left(\frac{a^{-2} b^4 c^5}{a^{-4} b^{-4} c^3}\right)^2 a^4 b^{16} c^4$$

$$20. \frac{p^{12} t^3 r}{p^2 t r} p^{10} t^2$$

$$23. \left(\frac{3xy^4}{5z^2}\right)^2 \frac{9x^2 y^8}{25z^4}$$

$$26. \frac{x^{-4} y^9}{z^{-2}} \frac{y^9 z^2}{x^4}$$

$$29. \left(\frac{2r^3 t^6}{5u^9}\right)^4 \frac{16r^{12} t^{24}}{625u^{36}}$$

$$32. \frac{p^{12} t^7 r^2}{p^2 t^7 r} p^{10} r$$

$$35. \frac{-2f^3 g^2 h^0}{8f^2 g^2} \frac{-f}{4}$$

$$38. \frac{14f^{-3} g^2 h^{-7}}{21k^3} \frac{2g^2}{3f^3 h^7 k^3}$$

$$41. \frac{r^3 t^{-1} x^{-5}}{tx^5} \frac{r^3}{t^2 x^{10}}$$

$$21. \frac{3m^{-3} r^4 p^2}{12t^4} \frac{r^4 p^2}{4m^3 t^4}$$

$$24. \left(\frac{3t^6 u^2 v^5}{9tuv^{21}}\right)^0 1$$

$$27. \frac{a^7 b^8 c^8}{a^5 b c^7} a^2 b^7 c$$

$$30. \left(\frac{3m^5 r^3}{4p^8}\right)^4 \frac{81m^{20} r^{12}}{256p^{32}}$$

$$33. \frac{p^4 t^{-3}}{r^{-2}} \frac{p^4 r^2}{t^3}$$

$$36. \frac{12m^{-4} p^2}{-15m^3 p^{-9}} \frac{4p^{11}}{-5m^7}$$

$$39. \frac{39t^4 uv^{-2}}{13t^{-3} u^7} \frac{3t^7}{u^6 v^2}$$

$$42. \frac{g^0 h^7 j^{-2}}{g^{-5} h^0 j^{-2}} g^5 h^7$$

43. 10^6 ; 10^8 ; about 10^2 or 100 times as many users as hosts

