-Key Concept and Vocabulary

Quotient of Powers Property

To divide powers with the same base, subtract their exponents.

Numbers:
$$\frac{3^6}{3^4} = 3^{6-4} = 3^2$$

Algebra:
$$\frac{a^m}{a^n} = a^{m-n}, a \neq 0$$



Visual Model

$$\frac{3^{6}}{3^{4}} = \frac{\sqrt[3]{3} \cdot \sqrt[3]{3} \cdot \sqrt[3]{3} \cdot \sqrt[3]{3} \cdot 3 \cdot 3}{\sqrt[3]{3} \cdot \sqrt[3]{3} \cdot \sqrt[3]{3}} = 3 \cdot 3 = 3^{2}$$

$$\frac{(-4)^4}{(-4)^2} = \frac{(\stackrel{1}{>4}) \cdot (\stackrel{1}{>4}) \cdot (-4) \cdot (-4)}{(\stackrel{1}{>4}) \cdot (\stackrel{1}{>4})}$$
$$= (-4) \cdot (-4)$$

$$=(-4)$$

Skill Examples

1.
$$\frac{7^5}{7^2} = 7^{5-2} = 7^3$$

2.
$$\frac{(-5)^9}{(-5)^4} = (-5)^{9-4} = (-5)^5$$

3.
$$\frac{x^8}{x^6} = x^{8-6} = x^2$$

Application Example

4. The population of a city is about $4 \cdot 5^6$. The land area is about 54 square miles. Find the average number of people per square mile.

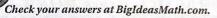
People per square mile =
$$\frac{4 \cdot 5^6}{5^4}$$

= $4 \cdot \frac{5^6}{5^4}$
= $4 \cdot 5^2$
= 100



There are about 100 people per square mile.

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Simplify the expression. Write your answer as a power.

5.
$$\frac{9^5}{9^4} =$$
 7. $\frac{2^7}{2^5} =$

6.
$$\frac{4^6}{4^2} =$$

7.
$$\frac{2^7}{6^5} =$$

8.
$$\frac{(-6)^7}{(-6)^3} =$$

9.
$$\frac{(-3)^8}{(-3)^5} =$$

8.
$$\frac{(-6)^7}{(-6)^3} =$$
 9. $\frac{(-3)^8}{(-3)^5} =$ 10. $\frac{(-8)^4}{(-8)^3} =$

11.
$$\frac{n^9}{1.5} =$$

12.
$$\frac{b^8}{h^2} =$$

11.
$$\frac{n^9}{n^5} =$$
 12. $\frac{b^8}{b^2} =$ 13. $\frac{y^{12}}{y^7} =$

14.
$$\frac{6^5 \cdot 6^2}{6^6} =$$
 15. $\frac{5^4 \cdot 5^5}{5^7} =$ 16. $\frac{a^8}{a^2 \cdot a^4} =$

15.
$$\frac{5^4 \cdot 5^5}{5^7} =$$

16.
$$\frac{a^8}{a^2 \cdot a^4} =$$

17.
$$\frac{3^{10}}{3^4} \cdot \frac{3^7}{3^5} =$$
 18. $\frac{8^5}{8^2} \cdot \frac{8^7}{8^3} =$ 19. $\frac{w^{14}}{w^3} \cdot \frac{w^6}{w^4} =$

18.
$$\frac{8^5}{8^2} \cdot \frac{8^7}{8^3} =$$

19.
$$\frac{w^{14}}{w^3} \cdot \frac{w^6}{w^4} =$$

20. **SOUND INTENSITY** The sound intensity of busy street traffic is 10⁷ times greater than the quietest noise a person can hear. The sound intensity of the front rows at a rock concert is 1011 times greater than the quietest noise a person can hear. How many times more intense is the sound in the front rows of a rock concert than the sound of busy street traffic?

Key Concept and Vocabulary

Product of Powers Property

To multiply powers with the same base, add their exponents.

Numbers:
$$2^3 \cdot 2^4 = 2^{3+4} = 2^7$$

Algebra: $a^m \cdot a^n = a^{m+n}$



Visual Model

$$2^3 \cdot 2^4 = (2 \cdot 2 \cdot 2) \cdot (2 \cdot 2 \cdot 2 \cdot 2)$$
$$= 2^7$$

$$(-4)^2 \cdot (-4)^3 = [(-4) \cdot (-4)][(-4) \cdot (-4) \cdot (-4)]$$

= $(-4)^5$

Skill Examples

1.
$$5^2 \cdot 5^5 = 5^{2+5} = 5^7$$

2.
$$(-3)^8 \cdot (-3)^2 = (-3)^{8+2} = (-3)^{10}$$

3.
$$(7^2)^3 = 7^2 \cdot 7^2 \cdot 7^2 = 7^{2+2+2} = 7^6$$

4.
$$(y^3)^4 = y^3 \cdot y^3 \cdot y^3 \cdot y^3 = y^{3+3+3+3} = y^{12}$$

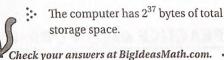
5.
$$(3x)^3 = 3x \cdot 3x \cdot 3x$$
$$= (3 \cdot 3 \cdot 3) \cdot (x \cdot x \cdot x)$$
$$= 3^3 \cdot x^3$$
$$= 27x^3$$

Application Example

6. A gigabyte of computer storage space is 230 bytes. A computer has a total storage space of 128 gigabytes. How many bytes of total storage space does the computer have? Write your answer as a power.

Notice that 128 can be written as a power, 2^7 .

Total number _ Number of bytes . Number of bytes in a gigabyte of gigabytes $=2^{30} \cdot 2^{7}$ $=2^{30+7}$ $=2^{37}$



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Simplify the expression. Write your answer as a power.

7.
$$8^3 \cdot 8^6 =$$
 9. $6^7 \cdot 6^5 =$ 9. 6

9.
$$6^7 \cdot 6^5 =$$

10
$$(-5)^3 \cdot (-5)^7 =$$

11
$$(-10)^6 \cdot (-10)^2 =$$

10.
$$(-5)^3 \cdot (-5)^7 =$$
 _____ **11.** $(-10)^6 \cdot (-10)^2 =$ _____ **12.** $(-2)^4 \cdot (-2)^5 =$ _____

13.
$$(9^4)^3 =$$
 _____ 15. $(12^3)^2 =$ _____

14.
$$(4^5)^3 =$$

15.
$$(12^3)^2 =$$

16.
$$(z^3)^3 =$$
 ______ **17.** $(n^5)^2 =$ _____ **18.** $(w^2)^4 =$ _____

17.
$$(n^5)^2 =$$

18.
$$(w^2)^4 =$$

Simplify the expression.

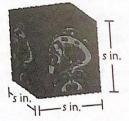
19.
$$(9y)^2 =$$
 _____ **20.** $(3b)^4 =$ _____ **21.** $(2a)^5 =$ ____

20.
$$(3b)^4 =$$

21.
$$(2a)^5 =$$

22. ARTIFACT A display case for the artifact is in the shape of a cube. Each side of the display case is four times the side length of the artifact. Write and simplify an expression for the volume of

the case.



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