

## Independent Practice

In Exercises 9–41, simplify, if possible.

9.  $4^2 \cdot 4^3$   $4^5$  or 1024

12.  $10^2 \cdot 10^9$   $10^{11}$

15.  $[(2x + 3)^3]^2$   $(2x + 3)^6$

18.  $[(5 + x)^3]^6$   $(5 + x)^{18}$

21.  $(4a)^2 \cdot a$   $16a^3$

24.  $(x \cdot x^2)^3 \cdot 3x$   $3x^{10}$

27.  $2x^3 \cdot (3x)^2$   $18x^5$

30.  $(-rs)(rs^3)^2$   $-r^3s^7$

33.  $(4a^2)^3(\frac{1}{2}a^3)^2$   $16a^{12}$

36.  $(-y)^4(-y)^3(-y)^2$   $-y^9$

39.  $(abc^2)^3(a^2b)^2$   $a^7b^5c^6$

10.  $6^5 \cdot 6^4$   $6^9$  or 10,077,696

13.  $x \cdot x^5$   $x^6$

16.  $(2x)^3$   $8x^3$

19.  $(-5a)^2$   $25a^2$

22.  $6^2 \cdot (6x^3)^2$   $6^4x^6$  or  $1296x^6$

25.  $(3a)^2 \cdot (-4a)^4$

28.  $3y^2 \cdot (2y)^3$   $24y^5$

31.  $(-2xy)^3(-x^2)$   $8x^5y^3$

34.  $(8b^3)^2(\frac{1}{4}b^2)^2$   $4b^{10}$

37.  $(2t)^3(-t^2)$   $-8t^5$

40.  $(r^2st^3)^2(s^4t)^3$   $r^4s^{14}t^9$

25.  $3^2(-4)^4a^6$  or  $2304a^6$

$(-9)^8$  or 43,046,721

11.  $[(-9)^2]^4$

14.  $(5^5)^4$   $5^{20}$

17.  $(3 \cdot 7)^4$   $21^4$  or 194,481

20.  $(16 \cdot 2)^2$   $32^2$  or 1024

23.  $[(-3xy)^2]^3$

26.  $(9a^3)^2 \cdot (2a)^3$

29.  $(-ab)(a^2b)^2$   $-a^5b^3$

32.  $(-3cd)^3(-d^2)$   $27c^3d^5$

35.  $(-x)^5(-x)^2(-x)^3$   $x^{10}$

38.  $(-w^3)(3w^2)^2$   $-9w^7$

41.  $(-3xy^2)^3(-2x^2y)^2$   
 $-108x^7y^8$

26.  $2^39^2a^9$  or  $648a^9$

44.  $(a^2 \cdot b)^3$   $8$

47.  $[(a + 4)^2]^3 \cdot (a + 4)$   
 $78,125$

In Exercises 42–47, evaluate the expression when  $a = 1$  and  $b = 2$ .

42.  $(a^4)^3$   $1$

43.  $b^3 \cdot b^4$   $128$

45.  $(a^2b)^5$   $32$

46.  $(b^2 \cdot b^3) \cdot (b^2)^4$   $8192$

In Exercises 48–50, say which number is larger.

48.  $(5 \cdot 7)^3$  or  $5 \cdot 7^3$   $(5 \cdot 7)^3$

49.  $5^4 \cdot 2^5$  or  $(5 \cdot 2)^5$   $(5 \cdot 2)^5$

50.  $(4^5 \cdot 4^{10})$  or  $4^{50}$   $4^{50}$



Pushed to the max by the algebra test, Tim's brain spontaneously combusted.

**Exercises****Simplify.**

1.  $y(y^5)$   
 $y^6$

2.  $n^2 \cdot n^7$   
 $n^9$

3.  $(-7x^2)(x^4)$   
 $-7x^6$

4.  $x(x^2)(x^4)$   
 $x^7$

5.  $m \cdot m^5$   
 $m^6$

6.  $(-x^3)(-x^4)$   
 $x^7$

7.  $(2a^2)(8a)$   
 $16a^3$

8.  $(rs)(rs^3)(s^2)$   
 $r^2s^6$

9.  $(x^2y)(4xy^3)$   
 $4x^3y^4$

10.  $\frac{1}{3}(2a^3b)(6b^3)$   
 $4a^3b^4$

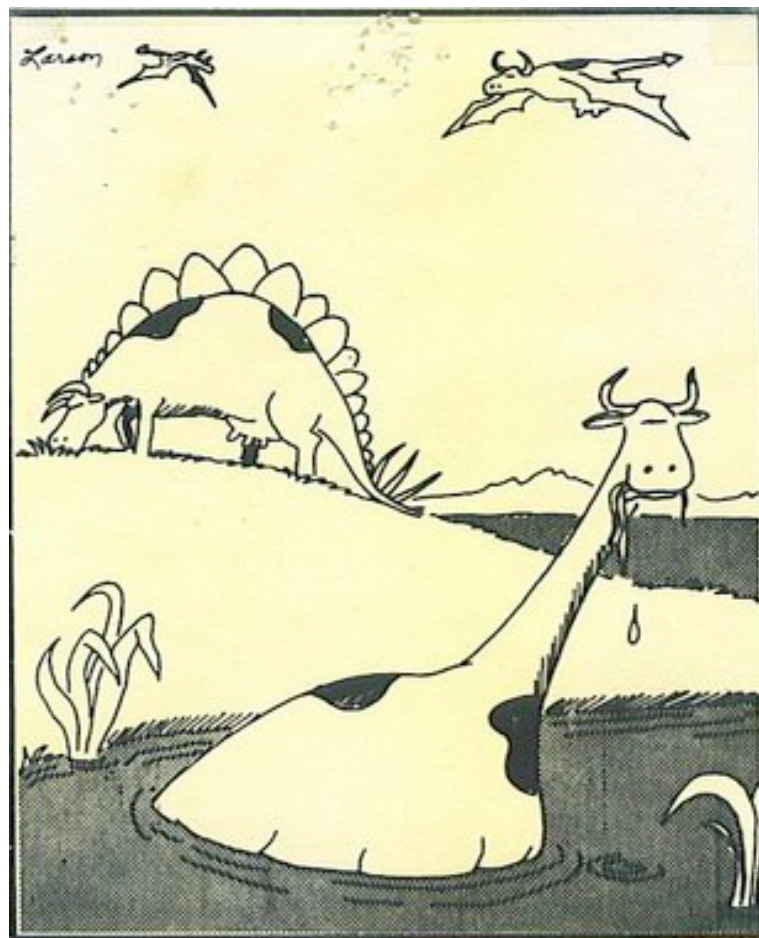
11.  $(-4x^3)(-5x^7)$   
 $20x^{10}$

12.  $(-3j^2k^4)(2jk^6)$   
 $-6j^3k^{10}$

13.  $(5a^2bc^3)\left(\frac{1}{5}abc^4\right)$   
 $a^3b^2c^7$

14.  $(-5xy)(4x^2)(y^4)$   
 $-20x^3y^5$

15.  $(10x^3yz^2)(-2xy^5z)$   
 $-20x^4y^6z^3$



Sixty-five million years ago, when cows ruled the earth

**Exercises****Simplify.**

1.  $(y^5)^2$   
 $y^{10}$

2.  $(n^7)^4$   
 $n^{28}$

3.  $(x^2)^5(x^3)$   
 $x^{13}$

4.  $-3(ab^4)^3$   
 $-3a^3b^{12}$

5.  $(-3ab^4)^3$   
 $-27a^3b^{12}$

6.  $(4x^2b)^3$   
 $64x^6b^3$

7.  $(4a^2)^2(b^3)$   
 $16a^4b^3$

8.  $(4x)^2(b^3)$   
 $16x^2b^3$

9.  $(x^2y^4)^5$   
 $x^{10}y^{20}$

10.  $(2a^3b^2)(b^3)^2$   
 $2a^3b^8$

11.  $(-4xy)^3(-2x^2)^3$   
 $512x^9y^3$

12.  $(-3j^2k^3)^2(2j^2k)^3$   
 $72j^{10}k^9$

13.  $(25a^2b)^3\left(\frac{1}{5}abc\right)^2$   
 $625a^8b^5c^2$

14.  $(2xy)^2(-3x^2)(4y^4)$   
 $-48x^4y^6$

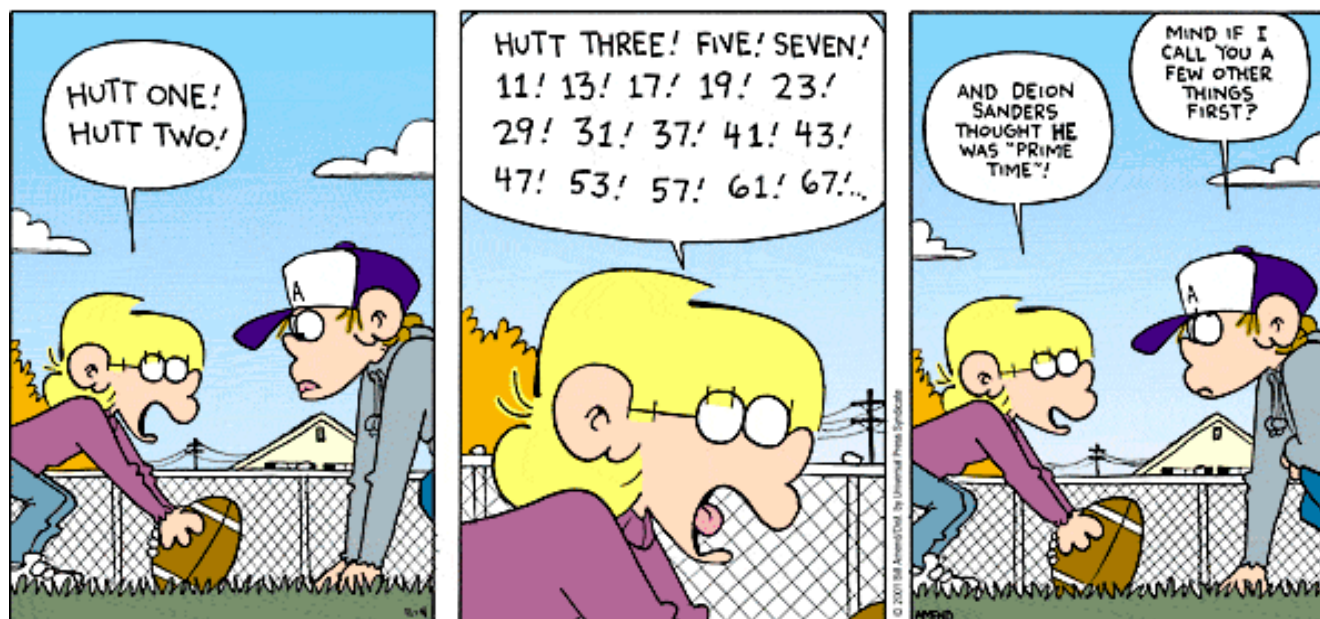
15.  $(2x^3y^2z^2)^3(x^2z)^4$   
 $8x^{17}y^6z^{10}$

16.  $(-2n^6y^5)(-6n^3y^2)(ny)^3$   
 $12n^{12}y^{10}$

17.  $(-3a^3n^4)(-3a^3n)^4$   
 $-243a^{15}n^8$

18.  $-3(2x)^4(4x^5y)^2$   
 $-768x^{14}y^2$





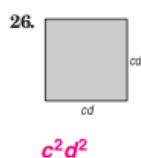
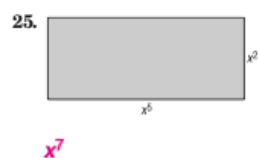
Determine whether each expression is a monomial. Write *yes* or *no*. Explain.

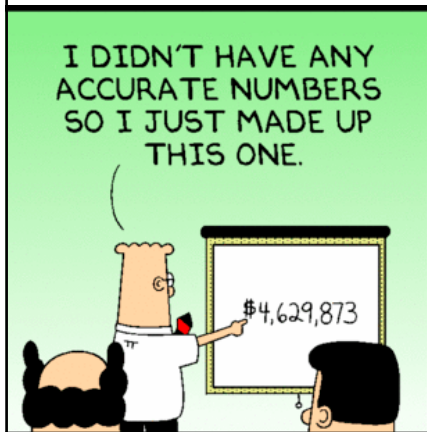
1. 11 **Yes; 11 is a real number and an example of a constant.**
2.  $a - b$  **No; This is the difference, not the product, of two variables.**
3.  $\frac{p^2}{q^2}$  **No; This is the quotient, not the product, of two variables.**
4.  $y$  **Yes; Single variables are monomials.**
5.  $j^3k$  **Yes; This is the product of two variables.**
6.  $2a + 3b$  **No; This is the sum of two monomials.**

Simplify.

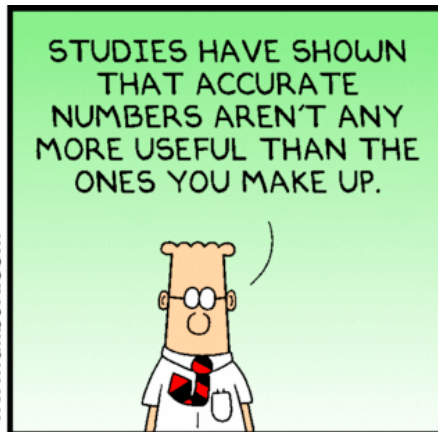
7.  $a^2(a^3)(a^6)$   **$a^{11}$**
8.  $x(x^2)(x^7)$   **$x^{10}$**
9.  $(y^2z)(yz^2)$   **$y^3z^3$**
10.  $(\ell^2k^2)(\ell^3k)$   **$\ell^5k^3$**
11.  $(e^2f^4)(e^2f^2)$   **$e^4f^6$**
12.  $(cd^2)(c^3d^2)$   **$c^4d^4$**
13.  $(2x^2)(3x^5)$   **$6x^7$**
14.  $(5a^7)(4a^2)$   **$20a^9$**
15.  $(4xy^3)(3x^3y^5)$   **$12x^4y^8$**
16.  $(7a^5b^2)(a^2b^3)$   **$7a^7b^5$**
17.  $(-5m^3)(3m^8)$   **$-15m^{11}$**
18.  $(-2c^4d)(-4cd)$   **$8c^5d^2$**
19.  $(10^2)^3$   **$10^6$  or 1,000,000**
20.  $(p^3)^{12}$   **$p^{36}$**
21.  $(-6p)^2$   **$36p^2$**
22.  $(-3y)^3$   **$-27y^3$**
23.  $(3pq^2)^2$   **$9p^2q^4$**
24.  $(2b^3c^4)^2$   **$4b^6c^8$**

**GEOMETRY** Express the area of each figure as a monomial.

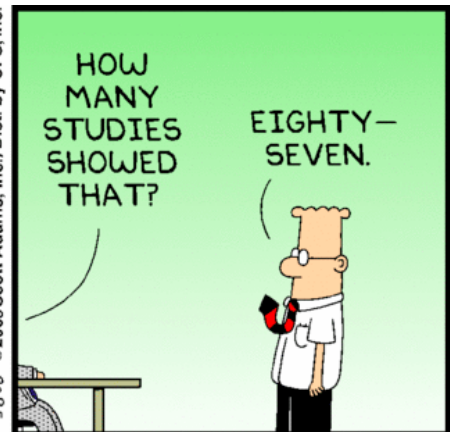




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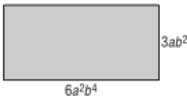


Determine whether each expression is a monomial. Write yes or no. Explain.

1.  $\frac{21a^2}{7b}$  **No; this involves the quotient, not the product, of variables.**
2.  $\frac{b^3c^2}{2}$  **Yes; this is the product of a number,  $\frac{1}{2}$ , and two variables.**

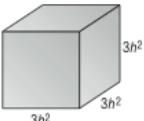
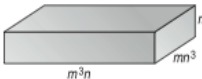
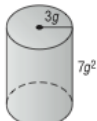
Simplify.

3.  $(-5x^2y)(3x^4)$   **$-15x^6y$**
4.  $(2ab^2c^2)(4a^3b^2c^2)$   **$8a^4b^4c^4$**
5.  $(3cd^4)(-2c^2)$   **$-6c^3d^4$**
6.  $(4g^3h)(-2g^5)$   **$-8g^8h$**
7.  $(-15xy^4)\left(-\frac{1}{3}xy^3\right)$   **$5x^2y^7$**
8.  $(-xy)^3(xz)$   **$-x^4y^3z$**
9.  $(-18m^2n)^2\left(-\frac{1}{6}mn^2\right)$   **$-54m^5n^4$**
10.  $(0.2a^2b^3)^2$   **$0.04a^4b^6$**
11.  $\left(\frac{2}{3}p\right)^2$   **$\frac{4}{9}p^2$**
12.  $\left(\frac{1}{4}cd^3\right)^2$   **$\frac{1}{16}c^2d^6$**
13.  $(0.4k^3)^3$   **$0.064k^9$**
14.  $[(4^2)^2]^2$   **$4^8$  or  $65,536$**

GEOMETRY Express the area of each figure as a monomial.

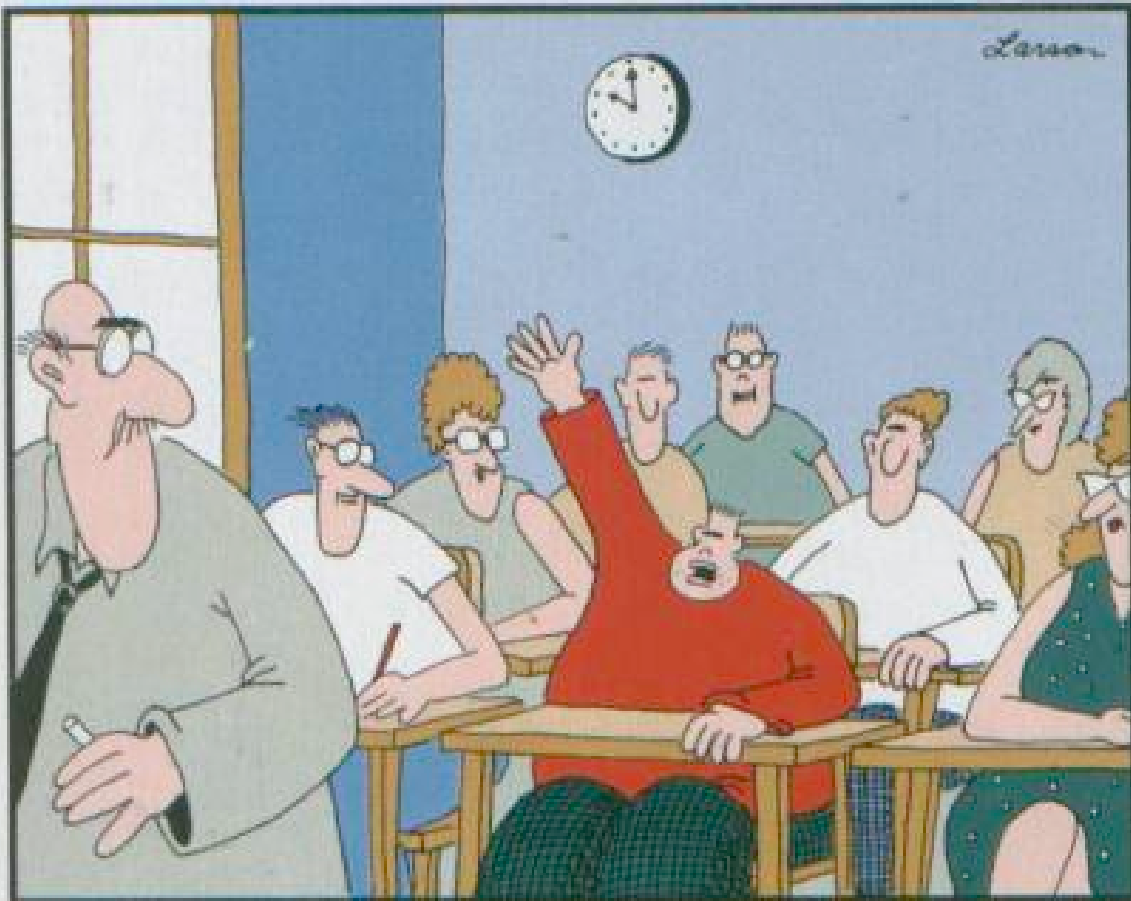
15.   **$18a^3b^6$**
16.   **$(25x^6)\pi$**
17.   **$12a^3c^4$**

GEOMETRY Express the volume of each solid as a monomial.

18.   **$27h^6$**
19.   **$m^4n^5$**
20.   **$(63g^4)\pi$**

21. **COUNTING** A panel of four light switches can be set in  $2^4$  ways. A panel of five light switches can set in twice this many ways. In how many ways can five light switches be set?  **$2^5$  or  $32$**

22. **HOBBIES** Tawa wants to increase her rock collection by a power of three this year and then increase it again by a power of two next year. If she has 2 rocks now, how many rocks will she have after the second year?  **$2^6$  or  $64$**



"Mr. Osborne, may I be excused?  
My brain is full."

## Independent Practice

In Exercises 6–17, rewrite the expression using positive exponents.

6.  $x^{-7} \frac{1}{x^2}$

7.  $x^{-9} \frac{1}{x^3}$

8.  $5x^{-4} \frac{5}{x^2}$

9.  $3x^{-2} \frac{3}{x^2}$

10.  $\frac{1}{2x^{-1}} \frac{x^3}{2}$

11.  $\frac{1}{4x^{-3}} \frac{x^5}{4}$

12.  $x^{-2}y^3 \frac{y^3}{x^2}$

13.  $x^6y^{-7}$

14.  $3x^{-3}y^{-8} \frac{3}{x^3y^8}$

15.  $6x^{-2}y^{-4} \frac{6}{x^2y^4}$

16.  $\frac{1}{7x^{-4}y^{-1}} \frac{x^4y}{7}$

17.  $\frac{1}{2x^{-10}y^{12}}$

In Exercises 18–29, evaluate the expression.

18.  $3^{-2} \frac{1}{9}$

19.  $2^{-4} \frac{1}{16}$

20.  $-4^0 \cdot \frac{1}{2^{-2}} - 4$

21.  $4^{-3} \cdot 4^2$

22.  $6^3 \cdot 6^{-1}$  36

23.  $8^4 \cdot 8^{-4}$  1

24.  $7^{-9} \cdot 7^9$  1

25.  $(5^{-3})^2$

26.  $(-4^{-2})^{-1}$  -16

27.  $-6 \cdot (-6)^{-1}$  1

28.  $5 \cdot 5^{-1}$  1

29.  $2^0 \cdot 3^{-3}$

In Exercises 30–41, rewrite the expression using positive exponents.

30.  $(-3)^0x$  x

31.  $(5y)^{-2} \frac{1}{25y^2}$

32.  $(-2x)^{-3} - \frac{1}{8x^3}$

33.  $(-4a)^0$  1

34.  $(-3x)^{-1} \cdot 2y - \frac{2y}{3x}$

35.  $(4xy)^{-2} \frac{1}{16x^2y^2}$

36.  $(3x)^{-1} \frac{1}{3x}$

37.  $(2a^{-3})^3$

38.  $\frac{4}{b^{-2}} 4b^2$

39.  $\frac{5}{a^{-4}} 5a^4$

40.  $\frac{1}{(4x)^{-3}} 64x^3$

41.  $\frac{1}{(2y)^{-5}}$  32y<sup>5</sup>

In Exercises 42–45, say if the graph of the function contains the point (0, 1).

42.  $y = -3^x$  No

43.  $y = 4^x$  Yes

44.  $y = 3 \cdot 1^x$  No

45.  $y = 50^x$  Yes

46. **Population of Missouri** Between 1970 and 1990, Missouri's population increased at the rate of 0.47% per year. The population,  $P$ , in year  $t$  is given by

$$P = 4,903,000 \cdot 1.0047^t$$

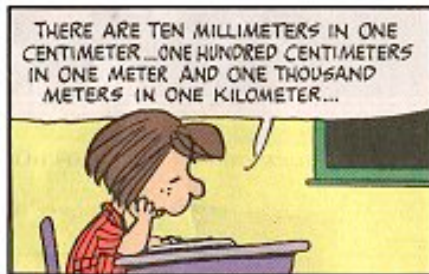
where  $t = 0$  corresponds to 1980. Find the population in 1970, 1980, and 1990.

$$4,678,406; 4,903,000; 5,138,376$$

47. **Population of Buffalo** Between 1970 and 1990, the population of Buffalo, New York, decreased at the rate of 0.82% per year. The population,  $P$ , in year  $t$  is given by

$$P = 1,025,000 \cdot 0.9918^t$$

where  $t = 0$  corresponds to 1980. Find the population in 1970, 1980, and 1990.



**Exercises**

Simplify. Assume that no denominator is equal to zero.

1.  $\frac{5^5}{5^2}$   **$5^3$  or  $125$**

2.  $\frac{m^6}{m^4}$   **$m^2$**

3.  $\frac{p^5 n^4}{p^2 n}$   **$p^3 n^3$**

4.  $\frac{a^2}{a}$   **$a$**

5.  $\frac{x^5 y^3}{x^5 y^2}$   **$y$**

6.  $\frac{-2y^7}{14y^5}$   **$-\frac{1}{7}y^2$**

7.  $\frac{xy^6}{y^4x}$   **$y^2$**

8.  $\left(\frac{2a^2b}{a}\right)^3$   **$8a^3b^3$**

9.  $\left(\frac{4p^4q^4}{3p^2q^2}\right)^3$   **$\frac{64}{27}p^6q^6$**

10.  $\left(\frac{2v^5w^3}{v^4w^3}\right)^4$   **$16v^4$**

11.  $\left(\frac{3r^6s^3}{2r^5s}\right)^4$   **$\frac{81}{16}r^4s^8$**

12.  $\frac{r^7s^7t^2}{s^3r^3t^2}$   **$r^4s^4$**

### Exercises

Simplify. Assume that no denominator is equal to zero.

$$1. \frac{2^2}{2^{-3}} \quad \mathbf{2^5 \text{ or } 32}$$

$$2. \frac{m}{m^{-4}} \quad \mathbf{m^5}$$

$$3. \frac{p^{-8}}{p^3} \quad \mathbf{\frac{1}{p^{11}}}$$

$$4. \frac{b^{-4}}{b^{-5}} \quad \mathbf{b}$$

$$5. \frac{(-x^{-1}y)^0}{4w^{-1}y^2} \quad \mathbf{\frac{w}{4y^2}}$$

$$6. \frac{(a^2b^3)^2}{(ab)^{-2}} \quad \mathbf{a^6b^8}$$

$$7. \frac{x^4y^0}{x^{-2}} \quad \mathbf{x^6}$$

$$8. \frac{(6a^{-1}b)^2}{(b^2)^4} \quad \mathbf{\frac{36}{a^2b^6}}$$

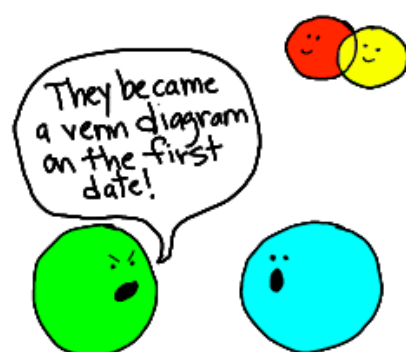
$$9. \frac{(3st)^2u^{-4}}{s^{-1}t^2u^7} \quad \mathbf{\frac{9s^3}{u^{11}}}$$

$$10. \frac{s^{-3}t^{-5}}{(s^2t^3)^{-1}} \quad \mathbf{\frac{1}{st^2}}$$

$$11. \left( \frac{4m^2n^2}{8m^{-1}\ell} \right)^0 \quad \mathbf{1}$$

$$12. \frac{(-2mn^2)^{-3}}{4m^{-6}n^4} - \frac{m^3}{32n^{10}}$$





1.  $\frac{6^5}{6^4}$   **$6^1$  or 6**

2.  $\frac{9^{12}}{9^8}$   **$9^4$  or 6561**

3.  $\frac{x^4}{x^2}$   **$x^2$**

4.  $\frac{r^3 s^2}{r^3 s^4}$   **$\frac{1}{s^2}$**

5.  $\frac{m}{m^3}$   **$\frac{1}{m^2}$**

6.  $\frac{9d^7}{3d^6}$   **$3d$**

7.  $\frac{12n^5}{36n}$   **$\frac{n^4}{3}$**

8.  $\frac{w^4 u^3}{w^4 u}$   **$u^2$**

9.  $\frac{a^3 b^5}{a b^2}$   **$a^2 b^3$**

10.  $\frac{m^7 n^2}{m^3 n^2}$   **$m^4$**

11.  $\frac{-21w^5 u^2}{7w^4 u^5}$   **$-\frac{3w}{u^3}$**

12.  $\frac{32x^3 y^2 z^5}{-8xyz^2}$   **$-4x^2 yz^3$**

13.  $\left(\frac{4p^7}{7s^2}\right)^2$   **$\frac{16p^{14}}{49s^4}$**

14.  $4^{-4}$   **$\frac{1}{256}$**

15.  $8^{-2}$   **$\frac{1}{64}$**

16.  $\left(\frac{5}{3}\right)^{-2}$   **$\frac{9}{25}$**

17.  $\left(\frac{9}{11}\right)^{-1}$   **$\frac{11}{9}$**

18.  $\frac{h^3}{h^{-6}}$   **$h^9$**

19.  $k^0(k^4)(k^{-6})$   **$\frac{1}{k^2}$**

20.  $k^{-1}(\ell^{-6})(m^3)$   **$\frac{m^3}{k\ell^6}$**

21.  $\frac{f^{-7}}{f^4}$   **$\frac{1}{f^{11}}$**

22.  $\left(\frac{16p^5 q^2}{2p^3 q^3}\right)^0$  **1**

23.  $\frac{f^{-5} g^4}{h^{-2}}$   **$\frac{g^4 h^2}{f^5}$**

24.  $\frac{15x^6 y^{-9}}{5xy^{-11}}$   **$3x^5 y^2$**

25.  $\frac{-15w^0 u^{-1}}{5u^3}$   **$-\frac{3}{u^4}$**

26.  $\frac{48x^6 y^7 z^5}{-6xy^5 z^6}$   **$-\frac{8x^5 y^2}{z}$**

Simplify. Assume that no denominator is equal to zero.

1.  $\frac{8^8}{8^4}$   **$8^4$  or 4096**

2.  $\frac{a^4b^6}{ab^3}$   **$a^3b^3$**

3.  $\frac{xy^2}{xy}$   **$y$**

4.  $\frac{m^5np}{m^4p}$   **$mn$**

5.  $\frac{5c^2d^3}{-4c^2d}$   **$-\frac{5d^2}{4}$**

6.  $\frac{8y^7z^6}{4y^6z^5}$   **$2yz$**

7.  $\left(\frac{4f^3g}{3h^6}\right)^3$   **$\frac{64f^9g^3}{27h^{18}}$**

8.  $\left(\frac{6w^5}{7p^6s^3}\right)^2$   **$\frac{36w^{10}}{49p^{12}s^6}$**

9.  $\frac{-4c^2}{24c^5}$   **$-\frac{1}{6c^3}$**

10.  $x^3(y^{-5})(x^{-8})$   **$\frac{1}{x^5y^5}$**

11.  $p(q^{-2})(r^{-3})$   **$\frac{p}{q^2r^3}$**

12.  $12^{-2}$   **$\frac{1}{144}$**

13.  $\left(\frac{3}{7}\right)^{-2}$   **$\frac{49}{9}$**

14.  $\left(\frac{4}{3}\right)^{-4}$   **$\frac{81}{256}$**

15.  $\frac{22r^3s^2}{11r^2s^{-3}}$   **$2rs^5$**

16.  $\frac{-15u^6u^{-1}}{5u^3}$   **$-\frac{3}{u^4}$**

17.  $\frac{8c^3d^2f^4}{4c^{-1}d^2f^{-3}}$   **$2c^4f^7$**

18.  $\left(\frac{x^{-3}y^5}{4^{-3}}\right)^0$   **$1$**

19.  $\frac{6f^{-2}g^3h^5}{54f^{-2}g^{-5}h^3}$   **$\frac{g^8h^2}{9}$**

20.  $\frac{-12t^{-1}u^5v^{-4}}{2t^{-3}uv^5}$   **$-\frac{6t^2u^4}{v^9}$**

21.  $\frac{r^4}{(3r)^3}$   **$\frac{r}{27}$**

22.  $\frac{m^{-2}n^{-5}}{(m^4n^3)^{-1}}$   **$\frac{m^2}{n^2}$**

23.  $\frac{(j^{-1}k^3)^{-4}}{j^3k^3}$   **$\frac{j}{k^{15}}$**

24.  $\frac{(2a^{-2}b)^{-3}}{5a^2b^4}$   **$\frac{a^4}{40b^7}$**

25.  $\left(\frac{q^{-1}r^3}{qr^{-2}}\right)^{-5}$   **$\frac{q^{10}}{r^{25}}$**

26.  $\left(\frac{7c^{-3}d^3}{c^5de^{-4}}\right)^{-1}$   **$\frac{c^8}{7d^2e^4}$**

27.  $\left(\frac{2x^3y^2z}{3x^4yz^{-2}}\right)^{-2}$   **$\frac{9x^2}{4y^2z^6}$**

**28. BIOLOGY** A lab technician draws a sample of blood. A cubic millimeter of the blood contains  $22^3$  white blood cells and  $22^5$  red blood cells. What is the ratio of white blood cells to red blood cells?  **$\frac{1}{484}$**

**29. COUNTING** The number of three-letter “words” that can be formed with the English alphabet is  $26^3$ . The number of five-letter “words” that can be formed is  $26^5$ . How many times more five-letter “words” can be formed than three-letter “words”? **676**

**CRITICAL THINKING about the Lesson** 1. No, the bases are not the same.

1. Can  $\frac{x^{10}}{y^4}$  be simplified? Why or why not?

2. Does  $\frac{x^{-4}}{x^{-5}}$  simplify as  $x$  or  $\frac{1}{x}$ ?  $x$

3. When you divide powers with the same base, do you add or subtract exponents?

4. What is the relationship between  $\frac{x^4}{x^2}$  and  $\frac{x^{-4}}{x^{-2}}$ ? Are they equivalent or are they reciprocals of each other? Explain.

Reciprocals, their product is 1.

### Independent Practice

In Exercises 5–16, evaluate the expression.

5.  $\frac{6^6}{6^4}$  36

6.  $\frac{8^3}{8^1}$  64

7.  $\frac{(-4)^5}{(4)^5}$  -1

8.  $\frac{(-3)^9}{(-3)^9}$  1

9.  $\frac{2^2}{2^{-3}}$  32

10.  $\frac{8^3 \cdot 8^2}{8^5}$  1

11.  $\frac{7^4 \cdot 7}{-7^7}$   $-\frac{1}{49}$

12.  $\left(\frac{3}{4}\right)^2 \frac{9}{16}$

13.  $\left(\frac{5}{3}\right)^3 \frac{125}{27}$

14.  $\left(-\frac{2}{3}\right)^3 - \frac{8}{27}$

15.  $\left(-\frac{4}{5}\right)^2 \frac{16}{25}$

16.  $\left(\frac{9}{6}\right)^{-1} \frac{2}{3}$

In Exercises 17–28, simplify the expression.

17.  $\left(\frac{2}{x}\right)^4 \frac{16}{x^4}$

18.  $\frac{x^4}{x^5} \frac{1}{x}$

19.  $\left(\frac{1}{x}\right)^6 \frac{1}{x^6}$

20.  $x^3 \cdot \frac{1}{x^2} x$

21.  $x^7 \cdot \frac{1}{x^9} \frac{1}{x^2}$

22.  $\frac{3x^2y^2}{3xy} \cdot \frac{6xy^3}{3y} 2x^2y^3$

23.  $\frac{4xy^3}{2y} \cdot \frac{5xy^{-3}}{x^2} \frac{10}{y}$

24.  $\frac{16x^3y}{-4xy^3} \cdot \frac{-2xy}{-x} - \frac{8x^2}{y}$

25.  $\frac{-9x^5y^7}{x^2y^3} \cdot \frac{(2xy)^2}{-6x^2y^2} 6x^3y^4$

26.  $\frac{6x^{-2}y^2}{xy^{-3}} \cdot \frac{(4x^2y)^{-2}}{xy^2} \frac{3y}{8x^6}$

27.  $\frac{7x^{-1}y^3}{x^2y^{-2}} \cdot \frac{(3xy^2)^{-1}}{xy} \frac{7y^2}{3x^5}$

28.  $\left(\frac{2xy^{-2}y^4}{3yx^{-1}}\right)^{-2} \cdot \left(\frac{4xy}{2x^{-1}y^3}\right)^2 \frac{9}{y^6}$

**Mercury Levels** In Exercises 29 and 30, use the information from Example 4.



**Express each number in standard notation.**

1.  $3.65 \times 10^5$

**365,000**

2.  $7.02 \times 10^{-4}$

**0.000702**

3.  $8.003 \times 10^8$

**800,300,000**

4.  $7.451 \times 10^6$

**7,451,000**

5.  $5.91 \times 10^0$

**5.91**

6.  $7.99 \times 10^{-1}$

**0.799**

7.  $8.9354 \times 10^{10}$

**89,354,000,000**

8.  $8.1 \times 10^{-9}$

**0.0000000081**

9.  $4 \times 10^{15}$

**4,000,000,000,000,000**

**Express each number in scientific notation.**

10. 0.0000456

**$4.56 \times 10^{-5}$**

11. 0.00001

**$1 \times 10^{-5}$**

12. 590,000,000

**$5.9 \times 10^8$**

13. 0.00000000012

**$1.2 \times 10^{-10}$**

14. 0.000080436

**$8.0436 \times 10^{-5}$**

15. 0.03621

**$3.621 \times 10^{-2}$**

16.  $433 \times 10^4$

**$4.33 \times 10^6$**

17.  $0.0042 \times 10^{-3}$

**$4.2 \times 10^{-6}$**

18. 50,000,000,000

**$5 \times 10^{10}$**

**Evaluate. Express each result in scientific and standard notation.**

1.  $\frac{1.4 \times 10^4}{2 \times 10^2}$

**$7 \times 10^3$ ; 70**

2.  $\frac{3 \times 10^{-12}}{2 \times 10^{-15}}$

**$1.5 \times 10^3$ ; 1500**

3.  $(3.2 \times 10^{-2})(2.0 \times 10^2)$

**$6.4 \times 10^0$ ; 6.4**

4.  $\frac{1.2672 \times 10^{-8}}{2.4 \times 10^{-12}}$

**$5.28 \times 10^3$ ; 5280**

5.  $(7.7 \times 10^5)(2.1 \times 10^2)$

**$1.617 \times 10^8$ ; 161,700,000**

6.  $\frac{9.72 \times 10^8}{7.2 \times 10^{10}}$

**$1.35 \times 10^{-2}$ ; 0.0135**

7.  $(3.3 \times 10^5)(1.5 \times 10^{-4})$

**$4.95 \times 10^1$ ; 49.5**

8.  $\frac{3.3 \times 10^{-12}}{1.1 \times 10^{-14}}$

**$3 \times 10^2$ ; 300**

9.  $\frac{4 \times 10^{-4}}{2.5 \times 10^2}$

**$1.6 \times 10^{-6}$ ; 0.0000016**

- 10. FUEL CONSUMPTION** North America burned  $4.5 \times 10^{16}$  BTU of petroleum in 1998. At this rate, how many BTU's will be burned in 9 years? **Source:** *The New York Times 2001 Almanac*

**$4.05 \times 10^{17}$**

- 11. OIL PRODUCTION** If the United States produced  $6.25 \times 10^9$  barrels of crude oil in 1998, and Canada produced  $1.98 \times 10^9$  barrels, what is the quotient of their production rates? Write a statement using this quotient. **Source:** *The New York Times 2001 Almanac*

**About 3.16; Sample answer: The United States produces more than 3 times the crude oil of Canada.**



**Express each number in standard notation.**

- |  |  |  |
|--|--|--|
| 1. $4 \times 10^3$<br><b>4000</b>        | 2. $2 \times 10^8$<br><b>200,000,000</b> | 3. $3.2 \times 10^5$<br><b>320,000</b>       |
| 4. $3 \times 10^{-6}$<br><b>0.000003</b> | 5. $9 \times 10^{-2}$<br><b>0.09</b>     | 6. $4.7 \times 10^{-7}$<br><b>0.00000047</b> |

**ASTRONOMY** Express the number in each statement in standard notation.

7. The diameter of Jupiter is  $1.42984 \times 10^5$  kilometers. **142,984**
8. The surface density of the main ring around Jupiter is  $5 \times 10^{-6}$  grams per centimeter squared. **0.000005**
9. The minimum distance from Mars to Earth is  $5.45 \times 10^7$  kilometers. **54,500,000**

**Express each number in scientific notation.**

- |  |   |  |
|--|---|--|
| 10. 41,000,000<br><b><math>4.1 \times 10^7</math></b>        | 11. 65,100<br><b><math>6.51 \times 10^4</math></b>  | 12. 283,000,000<br><b><math>2.83 \times 10^8</math></b>      |
| 13. 264,701<br><b><math>2.64701 \times 10^5</math></b>       | 14. 0.019<br><b><math>1.9 \times 10^{-2}</math></b> | 15. 0.000007<br><b><math>7 \times 10^{-6}</math></b>         |
| 16. 0.000010035<br><b><math>1.0035 \times 10^{-5}</math></b> | 17. 264.9<br><b><math>2.649 \times 10^2</math></b>  | 18. $150 \times 10^2$<br><b><math>1.5 \times 10^4</math></b> |

**Evaluate. Express each result in scientific and standard notation.**

- |   |   |
|---|---|
| 19. $(3.1 \times 10^7)(2 \times 10^{-5})$<br><b><math>6.2 \times 10^2</math>; 620</b>             | 20. $(5 \times 10^{-2})(1.4 \times 10^{-4})$<br><b><math>7.0 \times 10^{-6}</math>; 0.000007</b>      |
| 21. $(3 \times 10^3)(4.2 \times 10^{-1})$<br><b><math>1.26 \times 10^3</math>; 1260</b>           | 22. $(3 \times 10^{-2})(5.2 \times 10^9)$<br><b><math>1.56 \times 10^8</math>; 156,000,000</b>        |
| 23. $(2.4 \times 10^2)(4 \times 10^{-10})$<br><b><math>9.6 \times 10^{-8}</math>; 0.000000096</b> | 24. $(1.5 \times 10^{-4})(7 \times 10^{-5})$<br><b><math>1.05 \times 10^{-8}</math>; 0.0000000105</b> |
| 25. $\frac{5.1 \times 10^6}{1.5 \times 10^2}$<br><b><math>3.4 \times 10^4</math>; 34,000</b>      | 26. $\frac{7.2 \times 10^{-5}}{4 \times 10^{-3}}$<br><b><math>1.8 \times 10^{-2}</math>; 0.018</b>    |

**Express each number in standard notation.**

1.  $7.3 \times 10^7$   
**73,000,000**

2.  $2.9 \times 10^3$   
**2900**

3.  $9.821 \times 10^{12}$   
**9,821,000,000,000**

4.  $3.54 \times 10^{-1}$   
**0.354**

5.  $7.3642 \times 10^4$   
**73,642**

6.  $4.268 \times 10^{-6}$   
**0.000004268**

**PHYSICS** Express the number in each statement in standard notation.

7. An electron has a negative charge of  $1.6 \times 10^{-19}$  Coulomb. **0.00000000000000000016**

8. In the middle layer of the sun's atmosphere, called the chromosphere, the temperature averages  $2.78 \times 10^4$  degrees Celsius. **27,800**

**Express each number in scientific notation.**

9. 915,600,000,000  
 **$9.156 \times 10^{11}$**

10. 6387  
 **$6.387 \times 10^3$**

11. 845,320  
 **$8.4532 \times 10^5$**

12. 0.00000000814  
 **$8.14 \times 10^{-9}$**

13. 0.00009621  
 **$9.621 \times 10^{-5}$**

14. 0.003157  
 **$3.157 \times 10^{-3}$**

15. 30,620  
 **$3.062 \times 10^4$**

16. 0.0000000000112  
 **$1.12 \times 10^{-11}$**

17.  $56 \times 10^7$   
 **$5.6 \times 10^8$**

18.  $4740 \times 10^5$   
 **$4.74 \times 10^8$**

19.  $0.076 \times 10^{-3}$   
 **$7.6 \times 10^{-5}$**

20.  $0.0057 \times 10^3$   
**5.7 or  $5.7 \times 10^0$**

**Evaluate. Express each result in scientific and standard notation.**

21.  $(5 \times 10^{-2})(2.3 \times 10^{12})$   
 **$1.15 \times 10^{11}$ ; 115,000,000,000**

22.  $(2.5 \times 10^{-3})(6 \times 10^{15})$   
 **$1.5 \times 10^{13}$ ; 15,000,000,000,000**

23.  $(3.9 \times 10^3)(4.2 \times 10^{-11})$   
 **$1.638 \times 10^{-7}$ ; 0.0000001638**

24.  $(4.6 \times 10^{-4})(3.1 \times 10^{-1})$   
 **$1.426 \times 10^{-4}$ ; 0.0001426**

25.  $\frac{3.12 \times 10^3}{1.56 \times 10^{-3}}$   
 **$2.0 \times 10^6$ ; 2,000,000**

26.  $\frac{6.72 \times 10^3}{4.2 \times 10^8}$   
 **$1.6 \times 10^{-5}$ ; 0.000016**

27.  $\frac{1.17 \times 10^2}{5 \times 10^{-1}}$   
 **$2.34 \times 10^2$ ; 234**

28.  $\frac{1.82 \times 10^5}{9.1 \times 10^7}$   
 **$2.0 \times 10^{-3}$ ; 0.002**

29.  $\frac{1.68 \times 10^4}{8.4 \times 10^{-4}}$   
 **$2.0 \times 10^7$ ; 20,000,000**

30.  $\frac{2.015 \times 10^{-3}}{3.1 \times 10^2}$   
 **$6.5 \times 10^{-6}$ ; 0.0000065**

31. **BIOLOGY** A cubic millimeter of human blood contains about  $5 \times 10^6$  red blood cells. An adult human body may contain about  $5 \times 10^6$  cubic millimeters of blood. About how many red blood cells does such a human body contain? **about  $2.5 \times 10^{13}$  or 25 trillion**

32. **POPULATION** The population of Arizona is about  $4.778 \times 10^6$  people. The land area is about  $1.14 \times 10^5$  square miles. What is the population density per square mile?  
**about 42 people per square mile**

