Chapter 8 Exponents and Exponential Functions

pages 392–451

DIAGNOSING READINESS page 392

1. $\frac{7}{10} = 0.7$ **2.** $6\frac{2}{5} = 6\frac{4}{10} = 6.4$ **3.** $\frac{8}{1000} = 0.008$
4. $\frac{7}{2} = 3\frac{1}{2} = 3.5$ **5.** $\frac{3}{11} = 0.272727\ldots = 0.\overline{27}$
6. $(9 \div 3 + 4)^2 = (3 + 4)^2 = 7^2 = 49$ **7.** $5 + (0.3)^3 = 5 + 0.027 = 5.027$ **8.** $3 - (1.5)^2 = 3 - 2.25 = 0.75$
9. $64 \div 2^4 = 64 \div 16 = 4$ **10.** $[(-2)(5)]^2 = (-10)^2 = 100$
11. $(-2 - 5)^2 = (-7)^2 = 49$ **12.** $(-2)^3 + 5^2 = -8 + 25 = 17$ **13.** $5 - [3(-2)]^2 = 5 - (-6)^2 = 5 - 36 = -31$
14. $I = Prt = 1000 \cdot 0.03 \cdot 4 = 120$ [\$120]
15. $I = Prt$

$$P = \frac{I}{rt} = \frac{672}{0.07 \cdot 12} = 800 \text{ [\$800]}$$

16. $f(-2) = -2(-2)^2 = -8$; $f(0) = -2(0)^2 = 0$; $f(3.5) = -2(3.5)^2 = -24.5$; range $= \{-24.5, -8, 0\}$
17. $g(-2) = 10 - (-2)^3 = 10 + 8 = 18$; $g(0) = 10 - 0^3 = 10 - 0 = 10$; $g(3.5) = 10 - 3.5^3 = 10 - 42.875 = -32.875$; range $= \{-32.875, 10, 18\}$
18. $y(-2) = 5(-2) - 1 = -10 - 1 = -11$; $y(0) = 5 \cdot 0 - 1 = -1$; $y(3.5) = 5 \cdot 3.5 - 1 = 17.5 - 1 = 16.5$; range $= \{-11, -1, 16.5\}$ **19.** 9, 11 **20.** differences = 1, 2, 3, 4; next differences = 5, 6; next terms = 14, 20
21. 31, 37

8-1 Zero and Negative Exponents pages 394–399

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1. 8 **2.** $\frac{1}{16}$ **3.** 4 **4.** -27 **5.** -27 **6.** 3 **7.** $\frac{1}{2}$ **8.** -1 **9.** 4

Investigation

1a.

2^x	5^x	10^x
$2^4 = 16$	$5^4 = 625$	$10^4 = 10{,}000$
$2^3 = 8$	$5^3 = 125$	$10^3 = 1000$
$2^2 = 4$	$5^2 = 25$	$10^2 = 100$

1b. Left column: each term is (previous term) ÷ 2; middle column: each term is (previous term) ÷ 5; right column: each term = (previous term) ÷ 10.

2.

2^x	5^x	10^x
$2^1 = 2$	$5^1 = 5$	$10^1 = 10$
$2^0 = 1$	$5^0 = 1$	$10^0 = 1$
$2^{-1} = \frac{1}{2}$	$5^{-1} = \frac{1}{5}$	$10^{-1} = \frac{1}{10}$
$2^{-2} = \frac{1}{4}$	$5^{-2} = \frac{1}{25}$	$10^{-2} = \frac{1}{100}$

3. The values are all 1.

4a. $2^{-1} = 1\frac{1}{2^1}$ **4b.** $2^{-2} = \frac{1}{2^2}$ **4c.** $2^{-3} = \frac{1}{2^3}$

Check Understanding **1a.** $3^{-4} = \frac{1}{3^4} = \frac{1}{81}$ **1b.** $(-7)^0 = 1$
1c. $(-4)^{-3} = \frac{1}{(-4)^3} = \frac{1}{-64} = -\frac{1}{64}$ **1d.** $7^{-1} = \frac{1}{7}$
1e. $-3^{-2} = -(3^{-2}) = -\frac{1}{3^2} = -\frac{1}{9}$ **2a.** $11m^{-5} = \frac{11}{m^5}$
2b. $7s^{-4}t^2 = \frac{7t^2}{s^4}$ **2c.** $\frac{2}{a^{-3}} = 2a^3$ **2d.** $\frac{n^{-5}}{v^2} = \frac{1}{n^5v^2}$
3a. $n^{-3}w^0 = \frac{1}{n^3} = \frac{1}{(-2)^3} = \frac{1}{-8} = -\frac{1}{8}$ **3b.** $\frac{n^{-1}}{w^2} = \frac{1}{nw^2} = \frac{1}{(-2)5^2} = -\frac{1}{50}$ **3c.** $\frac{w^0}{n^4} = \frac{1}{n^4} = \frac{1}{(-2)^4} = \frac{1}{16}$ **3d.** $\frac{1}{nw^{-2}} = \frac{w^2}{n} = \frac{5^2}{-2} = -12.5$ **4.** $5400 \cdot 3^{-2} = \frac{5400}{3^2} = \frac{5400}{9} = 600$; $5400 \cdot 3^0 = 5400 \cdot 1 = 5400$. 5400 = bacterial population at beginning of 0th month. 600 = population 2 months earlier.

Exercises **1.** $-(2.57)^0 = -1$ **2.** $4^{-2} = \frac{1}{4^2} = \frac{1}{16}$
3. $(-5)^{-2} = \frac{1}{(-5)^2} = \frac{1}{25}$ **4.** $-5^{-2} = -\frac{1}{5^2} = -\frac{1}{25}$
5. $(-4)^{-2} = \frac{1}{(-4)^2} = \frac{1}{16}$ **6.** $-3^{-4} = -\frac{1}{3^4} = -\frac{1}{81}$
7. $2^{-6} = \frac{1}{2^6} = \frac{1}{64}$ **8.** $-12^{-1} = -\frac{1}{12}$ **9.** $\frac{1}{2^0} = \frac{1}{1} = 1$
10. $78^{-1} = \frac{1}{78}$ **11.** $(-4)^{-3} = \frac{1}{(-4)^3} = \frac{1}{-64} = -\frac{1}{64}$
12. $-4^{-3} = -\frac{1}{4^3} = -\frac{1}{64}$ **13.** $4n^{-2} = \frac{4}{n^2}$ **14.** $\frac{x^3}{2y^4} = \frac{1}{2x^{-3}y^4}$
15. $\frac{a^0}{3b^{-3}} = \frac{b^3}{3}$ **16.** $3xy^{-5} = \frac{3x}{y^5}$ **17.** $3ab^0 = 3a \cdot 1 = 3a$
18. $5x^{-4} = \frac{5}{x^4}$ **19.** $\frac{1}{x^{-7}} = x^7$ **20.** $\frac{1}{c^{-1}} = c$ **21.** $\frac{5^{-2}}{p} = \frac{1}{5^2p} = \frac{1}{25p}$ **22.** $a^{-4}c^0 = \frac{1}{a^4}$ **23.** $\frac{3x^{-2}}{y} = \frac{3}{x^2y}$ **24.** $\frac{7ab^{-2}}{3w} = \frac{7a}{3b^2w}$ **25.** $x^{-5}y^{-7} = \frac{1}{x^5y^7}$ **26.** $x^{-5}y^7 = \frac{y^7}{x^5}$ **27.** $\frac{8}{2c^{-3}} = 4c^3$
28. $\frac{7s}{5t^{-3}} = \frac{7st^3}{5}$ **29.** $\frac{6a^{-1}c^{-3}}{d^0} = \frac{6}{ac^3}$ **30.** $2^{-3}x^2z^{-7} = \frac{x^2}{8z^7}$
31. $9^0y^7t^{-11} = \frac{y^7}{t^{11}}$ **32.** $\frac{7s^0t^{-5}}{2^{-1}m^2} = \frac{14}{m^2t^5}$ **33.** $s^{-2} = \frac{1}{s^2} = \frac{1}{5^2} = \frac{1}{25}$ **34.** $(-3)^{-2} = \frac{1}{(-3)^2} = \frac{1}{9}$ **35.** $-(-3)^{-2} = -\frac{1}{(-3)^2} = -\frac{1}{9}$ **36.** $s^0 = 1$ **37.** $3 \cdot 5^{-2} = \frac{3}{5^2} = \frac{3}{25}$
38. $(2 \cdot 5)^{-2} = \frac{1}{10^2} = \frac{1}{100}$ **39.** $(-3)^{-4}5^2 = \frac{5^2}{(-3)^4} = \frac{25}{81}$
40. $\frac{1}{(-3)^{-4}5^2} = \frac{(-3)^4}{5^2} = \frac{81}{25}$ **41.** $5^2(-3)^{-3} = \frac{25}{(-3)^3} = \frac{25}{-27} = -\frac{25}{27}$ **42.** $(-3)^05^{-2} = \frac{1}{5^2} = \frac{1}{25}$ **43.** $5(-3)^35^{-1} = \frac{5(-27)}{5} = -27$ **44.** $2^{-4}(-3)^35^{-2} = \frac{(-3)^3}{2^45^2} = \frac{-27}{16 \cdot 25} = -\frac{27}{400}$ **45a.** Let w = number of weeks after this week. Allowance $= a = 2.56 \cdot 2^w = 2.56 \cdot 2^3 = 2.56 \cdot 8 = 20.48$ [\$20.48]; $2.56 \cdot 2^{-3} = \frac{2.56}{8} = 0.32$ [\$.32]
45b. No; after a year, the allowance would increase by a factor of $2^{52} = 4{,}500{,}000{,}000{,}000{,}000$. **46.** neg. **47.** pos.
48. pos. **49.** neg. **50.** neg. **51.** $\frac{1}{10} = 0.1 = 10^{-1}$

52. $\frac{1}{100} = 0.01 = 10^{-2}$ **53.** $\frac{1}{1000} = 10^{-3}$ **54.** $\frac{1}{10{,}000} = 10^{-4}$ **55.** $\frac{1}{100{,}000} = 10^{-5}$ **56.** $10^{-3} = 0.001$ **57.** $10^{-6} = 0.000001$ **58.** $7 \cdot 10^{-1} = 0.7$ **59.** $3 \cdot 10^{-2} = 0.03$ **60.** $5 \cdot 10^{-4} = 0.0005$ **61a.** $\frac{1}{5^2} = 5^{-2}; \frac{1}{5^1} = 5^{-1}; \frac{1}{5^0} = 5^0; \frac{1}{5^{-1}} = 5^1; \frac{1}{5^{-2}} = 5^2$ **61b.** $\frac{1}{5^{-4}} = 5^4$ **61c.** $\frac{1}{a^{-n}} = \frac{a^n}{1}$

62. The expression -3^0 means $-(3^0) = -(1) = -1$; the expression $(-3)^0$ means (any nonzero number)$^0 = 1$.

63. $45 \cdot (0.5)^0 = 45 \cdot 1 = 45$ **64.** $54 \cdot 3^{-2} = \frac{54}{3^2} = \frac{54}{9} = 6$ **65.** $\frac{5^{-2}}{10^{-3}} = \frac{10^3}{5^2} = \frac{1000}{25} = 40$ **66.** $\frac{4^{-1}}{9^0} = \frac{1}{4}$ **67.** $\frac{(-3)^{-4}}{-3} = \frac{1}{(-3)^5} = -\frac{1}{243}$ **68.** $c^b = (-4)^2 = 16$ **69.** $3^{-2} \cdot 2 = \frac{2}{3^2} = \frac{2}{9}$ **70.** $2^{-3} = \frac{1}{2^3} = \frac{1}{8}$ **71.** $2^{-4} = \frac{1}{2^4} = \frac{1}{16}$ **72.** $(-4)^{-3}2^{3\cdot 2} = \frac{2^6}{(-4)^3} = -\frac{64}{64} = -1$

73.

a	4	$\frac{1}{3}$	6	$\frac{7}{8}$	2
a^{-1}	$\frac{1}{4}$	3	$\frac{1}{6}$	$\frac{8}{7}$	0.5

74a. $a^n \cdot a^{-n} = a^{n+(-n)} = a^0 = 1, a \neq 0$ **74b.** a^n and a^{-n} are reciprocals for $a \neq 0$; $\frac{1}{a^n} = a^{-n}$ and $\frac{1}{a^{-n}} = a^n$. **75. A.** $4^{-1} = \frac{1}{4}$ **B.** $2^{-2} = \frac{1}{2^2} = \frac{1}{4}$ **C.** $-4^1 = -4$ **D.** $\frac{1}{2^2} = \frac{1}{4}$ **E.** $1^4 = 1$ **F.** $-2^{-2} = -\frac{1}{2^2} = -\frac{1}{4}$; A, B, D **76.** Check students' work.

77. No; when you form the reciprocal of an expression on the line you move the *entire* expression to the denominator; the reciprocal of $3x^{-2}$ is $\frac{1}{3x^{-2}}$. **78.** b^0 is b raised to the power 0, which equals 1, not $b \cdot 0$.

79a.

Number correct	Expression	Probability
0	p^0q^4	$\left(\frac{1}{5}\right)^0\left(\frac{4}{5}\right)^4 = 0.4096$
1	$4p^1q^3$	$4\left(\frac{1}{5}\right)^1\left(\frac{4}{5}\right)^3 = 0.4096$
2	$6p^2q^2$	$6\left(\frac{1}{5}\right)^2\left(\frac{4}{5}\right)^2 = 0.1536$
3	$4p^3q^1$	$4\left(\frac{1}{5}\right)^3\left(\frac{4}{5}\right)^1 = 0.0256$
4	p^4q^0	$\left(\frac{1}{5}\right)^4\left(\frac{4}{5}\right)^0 = 0.0016$

79b. 0 or 1; only blind guessing was allowed.

80. $\frac{30}{1 + 29 \cdot 2^{-2}} = \frac{30}{1 + 29\left(\frac{1}{2^2}\right)} = \frac{30}{1 + \frac{29}{4}} = 4\left(\frac{30}{4 + 29}\right) = 3.63$; $\frac{30}{1 + 29 \cdot 2^{-5}} = \frac{30}{1 + 29\left(\frac{1}{2^5}\right)} = \frac{30}{1 + \frac{29}{32}} = 32\left(\frac{30}{32 + 29}\right) = 15.74$; $\frac{30}{1 + 29 \cdot 2^{-10}} = \frac{30}{1 + 29\left(\frac{1}{2^{10}}\right)} = \frac{30}{1 + \frac{29}{1024}} = 1024\left(\frac{30}{1024 + 29}\right) = 29.17$; about 4 students; about 16 students; about 29 students

81. $2^3(5^0 - 6m^2) = 8(1 - 6m^2) = 8 - 48m^2$

82. $(-5)^2 - (0.5)^{-2} = 25 - \frac{1}{(0.5)^2} = 25 - \frac{1}{0.25} = 25 - 4 = 21$ **83.** $\frac{6}{m^2} + \frac{5m^{-2}}{3^{-3}} = \frac{6}{m^2} + \frac{5(3^3)}{m^2} = \frac{6}{m^2} + \frac{135}{m^2} = \frac{141}{m^2}$ **84.** $(0.8)^{-3} + 19^0 - 2^{-6} = \frac{1}{0.8^3} + 1 - \frac{1}{2^6} = \frac{1}{0.512} + 1 - \frac{1}{64} = 1.953125 + 1 - 0.015625 = 2.9375$

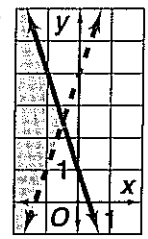
85. $\frac{2r^{-5}y^3}{n^2} \div \frac{r^2y^5}{2n} = \frac{2r^{-5}y^3}{n^2} \cdot \frac{2n}{r^2y^5} = \frac{4}{n^{2-1}r^{5+2}y^{5-3}} = \frac{4}{nr^7y^2}$

86. $2^{-1} - \frac{1}{3^{-2}} + 5\left(\frac{1}{2^2}\right) = \frac{1}{2} - 3^2 + \frac{5}{4} = \frac{2}{4} - 9 + \frac{5}{4} = -7\frac{1}{4}$

87.
$$n^{-3} = \left(\frac{1}{n}\right)^5$$
$$\frac{1}{n^3} = \frac{1}{n^5}$$
$$1 = \frac{1}{n^2}$$
$$n^2 = 1$$
$n = 1$ and -1

88. $2 \cdot 3^{-1} = \frac{2}{3}$ **89.** $\frac{3^{-2}b^2}{a^0b^2} = \frac{1}{3^2} = \frac{1}{9}$ **90.** $(4 \cdot 2 \cdot 1)^{-2} = 8^{-2} = \frac{1}{8^2} = \frac{1}{64}$ **91.** $-6(-6)^{-1} = \frac{-6}{-6} = 1$ **92.** $26 \cdot 10^{-2} = 0.26$ **93.** $0.2584 \cdot 10^3 = 258.4$

94.



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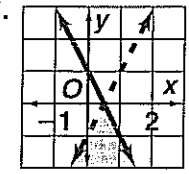

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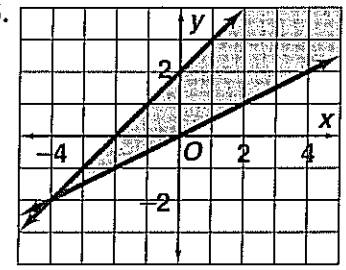
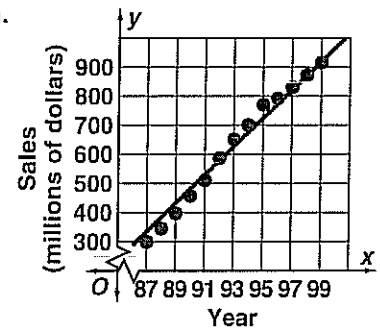


97a.



97b. Let $x = 87$ correspond to 1987 and $y =$ sales in \$millions. Trend line goes through points (87, 300) and (99, 915). **97c.** Slope is $\frac{915 - 300}{99 - 87} = \frac{615}{12} \approx 51$; $y = 51x - 4137$.

97d. In 2005, $x = 18$; $y = 51 \cdot 105 - 4137 = 1218$; sales are predicted to be \$1,218,000,000. **98.** $y = -x + 4$ **99.** $y = 5x - 2$ **100.** $y = \frac{2}{5}x - 3$ **101.** $y = -\frac{3}{11}x - 17$ **102.** $y = \frac{5}{9}x + \frac{1}{3}$ **103.** $y = 1.25x - 3.79$

8-2 Scientific Notation pages 400–404

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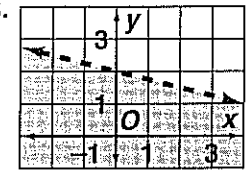
1. 60,000 **2.** 0.07 **3.** 820,000 **4.** 0.003 **5.** 34 **6.** 524 **7.** 367.8

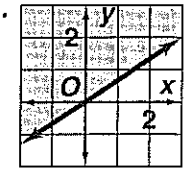
Check Understanding **1a.** yes **1b.** No; $52 > 10$. **1c.** No; $0.04 < 1$. **2a.** $267{,}000 = 2.67 \times 10^5$ **2b.** $46{,}205{,}000 = 4.6205 \times 10^7$ **2c.** $0.0000325 = 3.25 \times 10^{-5}$ **2d.** $0.000000009 = 9 \times 10^{-9}$ **2e.** 436 billion $= 436 \times 10^9 = 4.36 \times 10^2 \times 10^9 = 4.36 \times 10^{11}$ **3a.** $3.2 \times 10^{12} = 3{,}200{,}000{,}000{,}000$ **3b.** $5.07 \times 10^4 = 50{,}700$ **3c.** $5.6 \times 10^{-4} = 0.00056$ **3d.** $8.3 \times 10^{-2} = 0.083$ **4.** electron, proton, neutron **5.** The given numbers are, in scientific notation, 6.02×10^{-4}, 6.3×10^5, 6.7×10^1, and 6.1×10^{-1}. In increasing value these are 6.02×10^{-4}, 6.1×10^{-1}, 6.7×10^1, and 6.3×10^5. In original notation these are 60.2×10^{-5}, 61×10^{-2}, 0.067×10^3, and 63×10^4. **6a.** $2.5(6 \times 10^3) = (2.5 \cdot 6) \times 10^3 = 15 \times 10^3 = 1.5 \times 10^4$ **6b.** $0.4(2 \times 10^{-9}) = (0.4 \cdot 2) \times 10^{-9} = 0.8 \times 10^{-9} = 8 \times 10^{-10}$

Exercises **1.** No; $55 > 10$. **2.** yes **3.** No; $0.9 < 1$. **4.** yes **5.** yes **6.** No; $46 > 10$. **7.** $9{,}040{,}000{,}000 = 9.04 \times 10^9$ **8.** $0.02 = 2 \times 10^{-2}$ **9.** 9.3 million $= 9.3 \times 10^6$ **10.** $21{,}700 = 2.17 \times 10^4$ **11.** $0.00325 = 3.25 \times 10^{-3}$ **12.** $8{,}003{,}000 = 8.003 \times 10^6$ **13.** $0.00092 = 9.2 \times 10^{-4}$ **14.** $0.0156 = 1.56 \times 10^{-2}$ **15.** $5 \times 10^2 = 500$ **16.** $5 \times 10^{-2} = 0.05$ **17.** $2.04 \times 10^3 = 2040$ **18.** $7.2 \times 10^5 = 720{,}000$ **19.** $8.97 \times 10^{-1} = 0.897$ **20.** $1.3 \times 10^0 = 1.3$ **21.** $2.74 \times 10^{-5} = 0.0000274$ **22.** $4.8 \times 10^{-3} = 0.0048$ **23.** $10^{-3}, 10^{-1}, 10^0, 10^1, 10^5$ **24.** $6 \times 10^{-10}, 8 \times 10^{-8}, 9 \times 10^{-7}, 7 \times 10^{-6}$ **25.** $0.52 \times 10^{-3}, 50.1 \times 10^{-3}, 4.8 \times 10^{-1}, 56 \times 10^{-2}$ **26.** $5300 \times 10^{-1}, 5.3 \times 10^5, 0.53 \times 10^7, 530 \times 10^8$ **27.** C, A, B **28.** $8(7 \times 10^{-3}) = (8 \cdot 7) \times 10^{-3} = 56 \times 10^{-3} = 5.6 \times 10^{-2}$ **29.** $8(3 \times 10^{14}) = (8 \cdot 3) \times 10^{14} = 24 \times 10^{14} = 2.4 \times 10^{15}$ **30.** $0.2(3 \times 10^2) = (0.2 \cdot 3) \times 10^2 = 0.6 \times 10^2 = 6 \times 10^1$ **31.** $6(5.3 \times 10^{-4}) = (6 \cdot 5.3) \times 10^{-4} = 31.8 \times 10^{-4} = 3.18 \times 10^{-3}$ **32.** $0.3(8.2 \times 10^{-3}) = (0.3 \cdot 8.2) \times 10^{-3} = 2.46 \times 10^{-3}$ **33.** $0.5(6.8 \times 10^5) = (0.5 \cdot 6.8) \times 10^5 = 3.4 \times 10^5$ **34.** 5400 **35.** 7×10^1 **36.** 1×10^1 **37.** 4.6×10^{-2} **38.** 0.0005 **39.** 3×10^{-26} **40.** Answers may vary. Sample: Yes, if you regard the 1 in 1×10^5 as "understood" as happens when 1 is the coefficient of a term like x, then 10^5 is in scientific notation. **41.** First write million or millionths in scientific notation and then convert the entire expression to scientific notation. 48 million $= 48 \times 10^6 = 4.8 \times 10^7$; 48 millionths $= 48 \times 10^{-6} = 4.8 \times 10^{-5}$ **42.** $5745(2.87 \times 10^8) = (5745 \cdot 2.87) \times 10^8 = 16{,}488 \times 10^8 = 1.6488 \times 10^{12}$; spending will be about $\$1.65 \times 10^{12} = \$1.65$ trillion. **43.** $60(4.66 \times 10^8) = (60 \cdot 4.66) \times 10^8 = 279.6 \times 10^8 \approx 2.8 \times 10^{10}$ [instructions per minute]; $60(2.796 \times 10^8) = (60 \cdot 2.796) \times 10^{10} = 167.76 \times 10^{10} \approx 1.68 \times 10^{12}$ [instructions per hour] **44.** Standard notation; financial data in government or on Wall Street are generally given in whole dollar amounts or as millions, billions, or trillions. **45a.** 500 trillion $= 500 \times 10^{12} = 5 \times 10^{14}$ **45b.** If movie were lengthened by factor of 500 trillion, its screen time would become $10 \cdot 5 \times 10^{14}$ s $= 5 \times 10^{15}$ seconds or $\left(5 \times 10^{15}\text{ s}\right)\left(\frac{1\text{ hour}}{3600\text{ s}}\right)\left(\frac{1\text{ day}}{24\text{ h}}\right)\left(\frac{1\text{ year}}{365\text{ days}}\right) \approx 1.6 \times 10^8$ years. **46.** $(7.84 \times 10^9) \div 3 = (7.84 \div 3) \times 10^9 \approx 2.61 \times 10^9$ [people] **47a.** $V = \frac{4}{3}\pi r^3 = \frac{4}{3}\pi(2439)^3 \approx 6.08 \times 10^{10}$ **47b.** $\frac{4}{3}\pi(6378)^3 \approx 1.09 \times 10^{12}$ **47c.** $\frac{4}{3}\pi(60{,}268)^3 \approx 9.17 \times 10^{14}$; all units are in km^3. **48.** $\frac{1}{300} = 0.00\overline{3} = 3.\overline{3} \times 10^{-3}$ **49.** $90(1.2 \times 10^{-5}) = 108 \times 10^{-5} = 1.08 \times 10^{-3}$; the answer is D. **50.** The answer is G. **51.** 275 million $= 275 \times 10^6$; the answer is C. **52.** [2] $1000(8 \times 10^{-4}) = (1000 \cdot 8) \times 10^{-4} = 8000 \times 10^{-4} = 8 \times 10^{-1}$; apparent size $= 8 \times 10^{-1}$ mm $= 0.8$ mm
[1] minor computational error
53. $4(1.8)^0 = 4 \cdot 1 = 4$ **54.** $12 \cdot 2^{-2} = \frac{12}{2^2} = \frac{12}{4} = 3$ **55.** $6 \cdot 3^{-2} = \frac{6}{3^2} = \frac{6}{9} = \frac{2}{3}$ **56.** $\frac{4^3}{7^2} = \frac{64}{49}$ **57.** $\frac{3^{-2}}{9^0} = \frac{1}{3^2} = \frac{1}{9}$

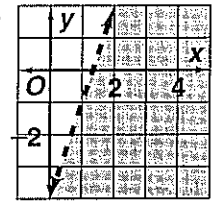
58.



59.



60.



8-3 Multiplication Properties of Exponents pages 405–410

Check Skills You'll Need For complete solutions see *Daily Skills Check and Lesson Quiz Transparencies* or *Presentation Pro CD-ROM.*

1. t^7 **2.** $(6 - m)^3$ **3.** $(r + 5)^5$ **4.** 5^3s^3 **5.** -625 **6.** 625 **7.** 1 **8.** $\frac{1}{625}$

Check Understanding **1a.** $5^3 \cdot 5^6 = 5^{3+6} = 5^9$ **1b.** $2^4 \cdot 2^{-3} = 2^{4+(-3)} = 2^1 = 2$ **1c.** $7^{-3} \cdot 7^2 \cdot 7^6 = 7^{-3+2+6} = 7^5$ **2a.** $a \cdot a^5 = a^{1+5} = a^6$ **2b.** $n^2 \cdot n^3 \cdot 7n = 7 \cdot n^2 \cdot n^3 \cdot n = 7n^{2+3+1} = 7n^6$ **2c.** $6y^2 \cdot 3y^3 \cdot 2y^{-4} = (6 \cdot 3 \cdot 2)(y^2 \cdot y^3 \cdot y^{-4}) = 36y^{2+3-4} = 36y^1 = 36y$ **3a.** $a \cdot b \cdot a^5 = a \cdot a^5 \cdot b = a^{1+5}b = a^6b$ **3b.** $2y^3 \cdot 7x^2 \cdot 2y^4 = (2 \cdot 7 \cdot 2)(x^2 \cdot y^3 \cdot y^4) = 28x^2y^{3+4} = 28x^2y^7$ **3c.** $m^2 \cdot n^{-2} \cdot 7m = 7m^{2+1}n^{-2} = \frac{7m^3}{n^2}$ **4a.** $(2.5 \times 10^8)(6 \times 10^3) = (2.5 \cdot 6)(10^8 \cdot 10^3) = 15 \times 10^{8+3} = 15 \times 10^{11} = 1.5 \times 10^{12}$ **4b.** $(1.5 \times 10^{-2})(3 \times 10^4) = (1.5 \cdot 3)(10^{-2} \cdot 10^4) = 4.5 \times 10^{-2+4} = 4.5 \times 10^2$ **4c.** $(9 \times 10^{-6})(7 \times 10^{-9}) = (9 \cdot 7)(10^{-6} \cdot 10^{-9}) = 63 \times 10^{-6-9} = 63 \times 10^{-15} = 6.3 \times 10^{-14}$ **5.** $160\text{ lb} \cdot (3.2 \times 10^4)\frac{\mu L}{\text{lb}} \cdot (5 \times 10^6)\frac{\text{cells}}{\mu L}$; $(160 \cdot 3.2 \cdot 5)(10^4 \cdot 10^6) = 2560 \times 10^{4+6} = 2560 \times 10^{10} = 2.56 \times 10^{13}$; about 2.56×10^{13} red blood cells.

Exercises **1.** $2^6 \cdot 2^4 = 2^{6+4} = 2^{10}$ **2.** $5^{-13} \cdot 10^5 = 5^{-13} \cdot (5 \cdot 2)^5 = 5^{-13} \cdot 5^5 \cdot 2^5 = 5^{-13+5} \cdot 2^5 = 5^{-8} \cdot 2^5 = \frac{2^5}{5^8}$ **3.** $10^{-6} \cdot 10^5 \cdot 10^1 = 10^{-6+5+1} = 10^0 = 1$ **4.** $(0.99)^3 \cdot (0.99)^0 = (0.99)^3 \cdot 1 = (0.99)^3$ **5.** $6^6 \cdot 6^{-2} \cdot 6^5 = 6^{6-2+5} = 6^9$ **6.** $(1.025)^2(1.025)^{-2} =$

$(1.025)^{2-2} = (1.025)^0 = 1$ **7.** $c^{-2}c^7 = c^{-2+7} = c^5$ **8.** $3r \cdot r^4 = 3r^{1+4} = 3r^5$ **9.** $5t^{-2} \cdot 2t^{-5} = (5 \cdot 2)(t^{-2} \cdot t^{-5}) = 10t^{-2-5} = 10t^{-7}$ **10.** $(7x^5)(8x) = (7 \cdot 8)(x^{5+1}) = 56x^6$ **11.** $3x^2 \cdot x^2 = 3x^{2+2} = 3x^4$ **12.** $(-2.4n^4)(2n^{-1}) = (-2.4 \cdot 2)(n^4 \cdot n^{-1}) = -4.8n^{4-1} = -4.8n^3$ **13.** $b^{-2} \cdot b^4 \cdot b = b^{-2+4+1} = b^3$ **14.** $(-2m^3)(3.5m^{-3}) = (-2 \cdot 3.5)(m^{3-3}) = -7m^0 = -7 \cdot 1 = -7$ **15.** $(15a^3)(-3a) = (15 \cdot -3)(a^{3+1}) = -45a^4$ **16.** $(x^5y^2)(x^{-6}y) = (x^5 \cdot x^{-6})(y^2 \cdot y) = x^{5-6} \cdot y^{2+1} = x^{-1} \cdot y^3 = \frac{y^3}{x}$ **17.** $(5x^5)(3y^6)(3x^2) = 5x^5 \cdot 3x^2 \cdot 3y^6 = 45x^{5+2}y^6 = 45x^7y^6$

18. $(4c^4)(ac^3)(3a^5c) = 12a^{1+5}c^{4+3+1} = 12a^6c^8$

19. $x^6 \cdot y^2 \cdot x^4 = x^6 \cdot x^4 \cdot y^2 = x^{6+4}y^2 = x^{10}y^2$

20. $a^6b^3 \cdot a^2b^{-2} = a^{6+2}b^{3-2} = a^8b^1 = a^8b$

21. $-m^2 \cdot 4r^3 \cdot 12r^{-4} \cdot 5m = -4 \cdot 12 \cdot 5 \cdot m^{2+1} \cdot r^{3-4} = -240m^3r^{-1} = -240\frac{m^3}{r}$

22. $(2 \times 10^3)(3 \times 10^2) = (2 \cdot 3)(10^3 \cdot 10^2) = 6 \times 10^{3+2} = 6 \times 10^5$ **23.** $(2 \times 10^6)(3 \times 10^3) = (2 \cdot 3) \cdot 10^{6+3} = 6 \times 10^9$ **24.** $(4 \times 10^6) \cdot 10^{-3} = 4 \times 10^{6-3} = 4 \times 10^3$ **25.** $(1 \times 10^3)(3.4 \times 10^{-8}) = 1 \cdot 3.4 \cdot 10^{3-8} = 3.4 \times 10^{-5}$ **26.** $(8 \times 10^{-5})(7 \times 10^{-3}) = 8 \cdot 7 \cdot 10^{-5-3} = 56 \times 10^{-8} = 5.6 \times 10^{-7}$

27. $(5 \times 10^7)(3 \times 10^{14}) = 5 \cdot 3 \cdot 10^{7+14} = 15 \times 10^{21} = 1.5 \times 10^{22}$ **28.** $5.88 \times 10^{12} \frac{\text{miles}}{\text{light-year}} \cdot 4.35$ light-years $= (5.88 \cdot 4.35) \times 10^{12}$ miles $= 25.578 \times 10^{12}$ miles $\approx 2.56 \times 10^{13}$ miles **29.** $120 \times 10^{12} \cdot 9 \times 10^6 = 120 \cdot 9 \cdot 10^{12+6} = 1080 \times 10^{18} = 1.08 \times 10^{21}$ [dollars]

30. distance $= (3 \times 10^5 \text{ km/s}) \cdot (1.28 \times 10^0 \text{ s}) = 3.84 \times 10^5$ km **31.** $5^2 \cdot 5^9 = 5^{11}$

32. $5^7 \cdot 5^{-4} = 5^3$ **33.** $2^{-3} \cdot 2^4 = 2^1$ **34.** $c^{-5} \cdot c^{11} = c^6$

35. $m^{-5} \cdot m^{-4} = m^{-9}$ **36.** $a \cdot a \cdot a^3 = a^5$ **37.** $a^{-4} \cdot a^4 = 1$ **38.** $a^{12} \cdot a^0 = a^{12}$ **39.** $x^3y^2 \cdot x^{-3} = y^2$ **40.** area $= 2x(3x^2 + x) = 6x^3 + 2x^2$ **41.** $(2x^2)^2 = 4x^4$ **42.** area $=$ base $\cdot$ height $= 4y^2(y^3 + 2) = 4y^5 + 8y^2$ **43.** area $= \frac{1}{2}bh = \frac{1}{2}(2c^3)(4c) = 4c^4$ **44.** The error is in multiplying the exponents instead of adding them. $(3x^2)(-2x^4) = 3(-2)x^{2+4} = -6x^6$ **45.** The error is in adding the coefficients instead of multiplying them. $4a^2 \cdot 3a^5 = (4 \cdot 3)a^{2+5} = 12a^7$ **46.** The error is in overlooking the exponent of 1 on x: $x^6 \cdot x \cdot x^3 = x^6 \cdot x^1 \cdot x^3 = x^{6+1+3} = x^{10}$ **47.** The error is in overlooking the fact that the exponent 4 applies only to the 3, and the 2 exponent applies only to the 2. You can't really simplify this expression unless you multiply it out. **48.** $(9 \times 10^7)(3 \times 10^{-16}) = (9 \cdot 3)(10^7 \cdot 10^{-16}) = 27 \times 10^{7-16} = 27 \times 10^{-9} = 2.7 \times 10^{-8}$ **49.** $(8 \times 10^{-3})(0.1 \times 10^9) = 8 \cdot 0.1 \times 10^6 = 8 \times 10^{-5}$ **50.** $(0.7 \times 10^{-12})(0.3 \times 10^8) = 0.21 \times 10^{-4} = 2.1 \times 10^{-5}$ **51.** $(0.4 \times 10^0)(3 \times 10^{-4}) = 1.2 \times 10^{-4}$

52. $(0.2 \times 10^5)(4 \times 10^{-12}) = 0.8 \times 10^{-7} = 8 \times 10^{-8}$

53. $(0.5 \times 10^{13})(0.3 \times 10^{-4}) = 0.15 \times 10^9 = 1.5 \times 10^8$

54. (1 mole) $\left(6.02 \times 10^{23} \frac{\text{atoms}}{\text{mole}}\right)\left(1.67 \times 10^{-24} \frac{\text{gram}}{\text{atom}}\right) = (6.02 \cdot 1.67)(10^{23} \cdot 10^{-24})$ g $= (10.0534 \times 10^{-1})$ g ≈ 1.01 g **55a.** $y^8 = y^1y^7 = y^2y^6 = y^3y^5 = y^4y^4$

55b. Answers may vary. Sample: $y = y^{-1}y^9 = y^{-2}y^{10} = y^{-3}y^{11} = y^{-4}y^{12} = \ldots$ **55c.** An infinite number; the sequence in Problem 55b could be carried on indefinitely; $y^8 = y^{-n}y^{8+n}, n = 1, 2, 3, 4, 5, \ldots$ **56a.** $1000 \cdot 1 \times 10^{-10} = 1 \times 10^{3-10} = 1 \times 10^{-7}$ [meter] **56b.** Longer; all numbers have the same power of ten; $4 > 1$ and $7.5 > 1$. A larger wavelength means a longer wavelength. **57.** x and y represent two different bases; fewer bases can be used if two terms have the same base, such as $x^3 \cdot x^5 = x^8$. **58.** $(6.5 \times 10^8)(9 \times 10^{-6}) = (6.5 \cdot 9)(10^{8-6}) = 58.5 \times 10^2 = 5.85 \times 10^3$ [meters] **59.** $(6.12 \times 10^5) \cdot (12.5 \times 10^8) = 6.12E5 \times 12.5E8 = 7.65E14 = 7.65 \times 10^{14}$

60. $(1.98 \times 10^{-3})(2.04 \times 10^{11}) = 4.0392 \times 10^8$

61. $(9.55 \times 10^7)(7.371 \times 10^{-15}) = 7.039305 \times 10^{-7}$

62. $(6.934 \times 10^{-9})(2.579 \times 10^{-4}) = 1.7882786 \times 10^{-12}$

63. $(3.35 \times 10^{25})(2 \times 10^8) = 6.7 \times 10^{33}$ [molecules]

64. $(8.4 \times 10^{11})(1.7 \times 10^{21}) = 14.28 \times 10^{32} \approx 1.4 \times 10^{33}$ [molecules] **65.** $\frac{1}{x^2 \cdot x^{-5}} = \frac{1}{x^{2-5}} = \frac{1}{x^{-3}} = x^3$

66. $\frac{1}{a^3 \cdot a^{-2}} = \frac{1}{a^{3-2}} = \frac{1}{a}$ **67.** $\frac{5}{c \cdot c^{-4}} = \frac{5}{c^{1-4}} = \frac{5}{c^{-3}} = 5c^3$

68. $2a^2(3a + 5) = 2 \cdot 3 \cdot a^{2+1} + 2 \cdot 5a^2 = 6a^3 + 10a^2$

69. $8m^3(m^2 + 7) = 8m^{3+2} + 8 \cdot 7m^3 = 8m^5 + 56m^3$

70. $-4x^3(2x^2 - 9x) = -8x^5 + 36x^4$ **71.** $3^x \cdot 3^{2-x} \cdot 3^2 = 3^{x+2-x+2} = 3^4 = 81$ **72.** $2^n \cdot 2^{n+2} \cdot 2 = 2^{n+n+2+1} = 2^{2n+3}$ **73.** $3^x \cdot 2^y \cdot 3^2 \cdot 2^x = 2^{x+y} \cdot 3^{x+2}$ **74.** $(a + b)^2 \cdot (a + b)^{-3} = (a + b)^{2-3} = (a + b)^{-1} = \frac{1}{a + b}$

75. $(t + 3)^7(t + 3)^{-5} = (t + 3)^{7-5} = (t + 3)^2$

76. $5^{x+1} \cdot 5^{1-x} = 5^{x+1+1-x} = 5^2 = 25$

77a. $(1.3 \times 10^{-3})(1.5 \times 10^{-3})(9.4 \times 10^{-4}) = 1.3 \cdot 1.5 \cdot 9.4 \cdot 10^{-3-3-4} = 18.33 \times 10^{-10} = 1.833 \times 10^{-9}$ [km^3] **77b.** (1.3 m)(1.5 m)(0.94 m) $= 1.833$ m^3 **78.** $\left(\frac{7.7 \text{ cm}}{1.1 \times 10^{-4} \text{ m}}\right)\left(\frac{1 \text{ m}}{100 \text{ cm}}\right) = 700$; 700 times

79. $(2x^2y^3)(4xy^{-2}) = 8x^{2+1}y^{3-2} = 8x^3y$; the answer is D.

80. Answer is F. **81. A.** $(3.84 \times 10^{-2})(3.84 \times 10^2) = 3.84^2 = 14.7$ **B.** $\frac{1}{12} \cdot 12 = 1$; the answer is A. **82. A.** slope $= -\frac{1}{3}$ **B.** $3^5 \cdot 3^2 \cdot 3^{-9} = 3^{-2}$; B is greater, being positive; the answer is B. **83.** [2] $365 \cdot 4.7 \times 10^7 = 1715.5 \times 10^7 \approx 1.7 \times 10^{10}$ [diapers] [1] no work shown OR answer not written in scientific notation **84.** [4] **a.** $A = 4r^2$ **b.** $4(5)^2 = 100$ [in.^{2}] **c.** $A = d^2$; $d = \sqrt{A} = \sqrt{144} = 12$ [in.] [3] radius found in (c) but not the diameter [2] only two questions answered correctly [1] only one question answered correctly

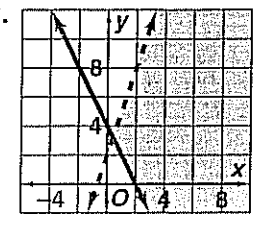
85. $1{,}280{,}000 = 1.28 \times 10^6$ **86.** $0.0035 = 3.5 \times 10^{-3}$

87. $0.00009 = 9 \times 10^{-5}$ **88.** 6.2 million $= 6.2 \times 10^6$

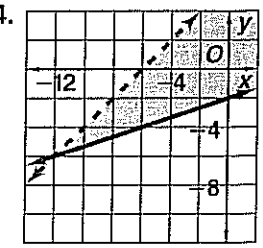
89. $8.76 \times 10^8 = 876{,}000{,}000$ **90.** $1.052 \times 10^{-3} = 0.001052$ **91.** $9.1 \times 10^{11} = 910{,}000{,}000{,}000$

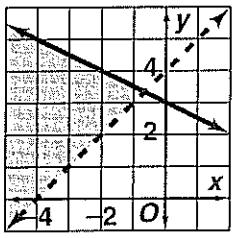
92. $2.9 \times 10^{-4} = 0.00029$

93.



94.



95. 

96. $A(3) = 10 + (3 - 1)(4) = 10 + 2 \cdot 4 = 18$; $A(7) = 10 + (7 - 1)(4) = 10 + 6 \cdot 4 = 34$; $A(10) = 10 + (10 - 1)(4) = 10 + 9 \cdot 4 = 46$ **97.** $A(3) = -5 + (3 - 1)(2) = -5 + 2 \cdot 2 = -1$; $A(7) = -5 + (7 - 1)(2) = -5 + 6 \cdot 2 = 7$; $A(10) = -5 + (10 - 1)(2) = -5 + 9 \cdot 2 = 13$ **98.** $A(3) = 12 + (3 - 1)(-4) = 12 + 2 \cdot -4 = 4$; $A(7) = 12 + (7 - 1)(-4) = 12 + 6 \cdot -4 = -12$; $A(10) = 12 + (10 - 1)(-4) = 12 + 9 \cdot -4 = -24$; **99.** $A(3) = 1.2 + (3 - 1)(-4) = 1.2 + 2(-4) = -6.8$; $A(7) = 1.2 + (7 - 1)(-4) = 1.2 + 6(-4) = -22.8$; $A(10) = 1.2 + (10 - 1)(-4) = 1.2 + 9(-4) = -34.8$

8-4 More Multiplication Properties of Exponents *pages 411–416*

Check Skills You'll Need For complete solutions see *Daily Skills Check and Lesson Quiz Transparencies* or *Presentation Pro CD-ROM.*

1. 3^6 **2.** 2^{12} **3.** 5^{28} **4.** 7^3 **5.** x^6 **6.** a^6 **7.** $\frac{1}{y^6}$ **8.** $\frac{1}{n^6}$

Investigation 1. $(3^6)^2 = 3^6 \cdot 3^6 = 3^{6+6} = 3^{6 \cdot 2} = 3^{12}$ **2.** $(5^4)^3 = 5^4 \cdot 5^4 \cdot 5^4 = 5^{4+4+4} = 5^{4 \cdot 3} = 5^{12}$ **3.** $(2^7)^4 = 2^7 \cdot 2^7 \cdot 2^7 \cdot 2^7 = 2^{7+7+7+7} = 2^{7 \cdot 4} = 2^{28}$ **4.** $(a^3)^2 = a^3 \cdot a^3 = a^{3+3} = a^{3 \cdot 2} = a^6$ **5.** $(g^4)^3 = g^4 \cdot g^4 \cdot g^4 = g^{4+4+4} = g^{4 \cdot 3} = g^{12}$ **6.** $(c^3)^4 = c^3 \cdot c^3 \cdot c^3 \cdot c^3 = c^{3+3+3+3} = c^{3 \cdot 4} = c^{12}$ **7a.** The power of the result is the product of the powers in the original expression.

7b. $(8^6)^3 = 8^{6 \cdot 3} = 8^{18}$

Check Understanding 1. $(a^4)^7 = a^{4 \cdot 7} = a^{28}$; $(a^{-4})^7 = a^{-4 \cdot 7} = a^{-28} = \frac{1}{a^{28}}$ **2a.** $(n^4)^3 \cdot n^5 = n^{4 \cdot 3} n^5 = n^{12+5} = n^{17}$ **2b.** $t^2(t^7)^{-2} = t^2 \cdot t^{7(-2)} = t^2 \cdot t^{-14} = t^{2-14} = t^{-12} = \frac{1}{t^{12}}$ **2c.** $(a^4)^2 \cdot (a^2)^5 = a^{4 \cdot 2} \cdot a^{2 \cdot 5} = a^8 \cdot a^{10} = a^{18}$

3a. $(2z)^4 = 2^4 \cdot z^4 = 16z^4$ **3b.** $(4g^5)^{-2} = 4^{-2} \cdot (g^5)^{-2} = \frac{1}{4^2} \cdot g^{5(-2)} = \frac{1}{16} \cdot g^{-10} = \frac{1}{16g^{10}}$ **3c.** $(3t^0)^4 = 3^4 = 81$

4a. $(c^2)^3(3c^5)^4 = (c^2)^3 \cdot 3^4 \cdot (c^5)^4 = c^6 \cdot 81 \cdot c^{20} = 81c^6c^{20} = 81c^{26}$ **4b.** $(2a^3)^5(3ab^2)^3 = 2^5(a^3)^5 \cdot 3^3 \cdot a^3 \cdot (b^2)^3 = 2^5a^{15} \cdot 27a^3 \cdot b^6 = 864a^{18}b^6$

4c. $(6mn)^3(5m^{-3})^2 = 6^3m^3n^3 \cdot 5^2m^{-6} = 5400m^{-3}n^3 = 5400\frac{n^3}{m^3}$ **5a.** $(1.45 \times 10^{-1})(3.6 \times 10^6) = (1.45 \cdot 3.6)(10^{-1} \cdot 10^6) = 5.22 \times 10^5$ [joules]

5b. $\frac{9 \times 10^{13} \text{ joules}}{5.22 \times 10^5 \text{ joules/hour}} \approx 1.7 \times 10^8$ hours

Exercises 1. $(c^5)^2 = c^{5 \cdot 2} = c^{10}$ **2.** $(c^2)^5 = c^{2 \cdot 5} = c^{10}$ **3.** $(n^8)^4 = n^{8 \cdot 4} = n^{32}$ **4.** $(q^{10})^{10} = q^{10 \cdot 10} = q^{100}$ **5.** $(c^5)^3c^4 = c^{5 \cdot 3}c^4 = c^{15}c^4 = c^{19}$ **6.** $(d^3)^5(d^3)^0 = d^{3 \cdot 5} \cdot 1 = d^{15}$ **7.** $(t^2)^{-2}(t^2)^{-5} = t^{2(-2)}t^{2(-5)} = t^{-4}t^{-10} = t^{-14} = \frac{1}{t^{14}}$ **8.** $(x^3)^{-1}(x^2)^5 = x^{3(-1)}x^{2 \cdot 5} = x^{-3}x^{10} = x^7$

9. $(5y)^4 = 5^4 \cdot y^4 = 625y^4$ **10.** $(4m)^5 = 4^5 \cdot m^5 = 1024m^5$ **11.** $(7a)^2 = 7^2 \cdot a^2 = 49a^2$ **12.** $(12g^4)^{-1} = 12^{-1} \cdot g^{4(-1)} = 12^{-1}g^{-4} = \frac{1}{12g^4}$ **13.** $(6y^2)^2 = 6^2 \cdot (y^2)^2 = 36y^4$ **14.** $(3n^6)^4 = 3^4n^{6 \cdot 4} = 81n^{24}$

15. $(2y^4)^{-3} = 2^{-3}y^{4(-3)} = \frac{1}{2^3}y^{-12} = \frac{1}{8y^{12}}$ **16.** $(2p^6)^0 = 1$

17. $(x^2)^5(x^3)^2 = x^{2 \cdot 5}x^{3 \cdot 2} = x^{10}x^6 = x^{16}$ **18.** $(2xy)^3x^2 = 2^3x^3y^3x^2 = 8x^5y^3$ **19.** $(mg^4)^{-1}(mg^4) = (mg^4)^0 = 1$

20. $(c^{-2})^3c^{-12} = c^{-2 \cdot 3}c^{-12} = c^{-6}c^{-12} = c^{-18} = \frac{1}{c^{18}}$

21. $(3b^{-2})^2(a^2b^4)^3 = 3^2b^{-4}a^6b^{12} = 9a^6b^8$

22. $(2a^2c^4)^{-5}(c^{-1}a^7)^6 = 2^{-5}a^{-10}c^{-20}c^{-6}a^{42} = \frac{1}{32}a^{32}c^{-26} = \frac{a^{32}}{32c^{26}}$ **23.** $(4 \times 10^5)^2 = 4^2 \cdot (10^5)^2 = 16 \cdot 10^{5 \cdot 2} = 16 \cdot 10^{10} = 1.6 \times 10^{11}$ **24.** $(3 \times 10^5)^2 = 3^2 \cdot 10^{5 \cdot 2} = 9 \times 10^{10}$ **25.** $(2 \times 10^{-10})^3 = 2^3 \cdot 10^{-10 \cdot 3} = 8 \times 10^{-30}$ **26.** $(2 \times 10^{-3})^3 = 2^3 \cdot 10^{-3 \cdot 3} = 8 \times 10^{-9}$

27. $(7 \times 10^4)^2 = 7^2 \cdot 10^{4 \cdot 2} = 49 \cdot 10^8 = 4.9 \times 10^9$

28. $(6 \times 10^{12})^2 = 6^2 \cdot 10^{12 \cdot 2} = 36 \cdot 10^{24} = 3.6 \times 10^{25}$

29. $(4 \times 10^8)^{-2} = 4^{-2} \cdot 10^{8(-2)} = \frac{1}{16} \cdot 10^{-16} = 0.0625 \cdot 10^{-16} = 6.25 \times 10^{-18}$ **30.** $(3.5 \times 10^{-4})^3 = 3.5^3 \cdot 10^{-4 \cdot 3} = 42.875 \cdot 10^{-12} = 4.2875 \times 10^{-11}$

31. $(9.5 \times 10^{-4})^3 = 9.5^3 \cdot 10^{-4 \cdot 3} = 857.375 \cdot 10^{-12} = 8.57375 \times 10^{-10}$ [m^3] **32.** $(x^2)^3 = x^6$ **33.** $(m^{-4})^3 = m^{-12}$ **34.** $(b^2)^4 = b^8$ **35.** $(y^{-4})^{-3} = y^{12}$ **36.** $(n^9)^0 = 1$

37. $7(c^1)^8 = 7c^8$ **38.** $(5x^{-2})^2 = 25x^{-4}$ **39.** $(3x^3y^0)^3 = 27x^9$ **40.** $(m^2n^3)^{-3} = \frac{1}{m^6n^9}$ **41.** $x^5 + x^5 = 2x^5$ is correct; x^{10} equals $x^5 \cdot x^5$. **42.** $(4.1)^5 \cdot (4.1)^{-5} = (4.1)^{5+(-5)} = (4.1)^0 = 1$ **43.** $3^2(3x)^3 = 9 \cdot 3^3x^3 = 243x^3$ **44.** $(b^5)^3b^2 = b^{5 \cdot 3}b^2 = b^{15}b^2 = b^{17}$ **45.** $(-5x)^2 + 5x^2 = (-5)^2x^2 + 5x^2 = 25x^2 + 5x^2 = 30x^2$ **46.** $(2x^{-3})^2 \cdot (0.2x)^2 = 2^2x^{-6} \cdot 0.2^2x^2 = 4 \cdot 0.04x^{-6+2} = 0.16x^{-4} = \frac{0.16}{x^4}$

47. $(-2a^2b)^3(ab)^3 = (-2)^3a^6b^3a^3b^3 = -8a^9b^6$

48. $(3^7)^2 \cdot (3^{-4})^3 = 3^{14} \cdot 3^{-12} = 3^2 = 9$

49. $(10^3)^4(4.3 \times 10^{-8}) = 10^{12} \cdot 4.3 \times 10^{-8} = 4.3 \times 10^{12-8} = 4.3 \times 10^4$ **50.** $(4xy^2)^4(-y)^{-3} = 4^4x^4y^8(-y^3) = -256x^4y^5$ **51a.** $6(2x)^2 = 6 \cdot 2^2x^2 = 6 \cdot 4x^2 = 24x^2$; $6(4x)^2 = 6 \cdot 4^2x^2 = 96x^2$ **51b.** $\frac{96x^2}{24x^2} = 4$ [times] **51c.** $(2x)^3 = 2^3x^3 = 8x^3$; $(4x)^3 = 4^3x^3 = 64x^3$

51d. $\frac{64x^3}{8x^3} = 8$ [times] **52.** $m^4 \cdot n^4 = (mn)^4$

53. $(a^5)(b^5)(a^0) = (ab)^5$ **54.** $49x^2y^2z^2 = (7xyz)^2$

55. $\frac{12x^2}{3y^{-2}} = 4x^2y^2 = (2xy)^2$ **56.** If $(a^c)^d = a^{c \cdot d} = a^n$, then $cd = n$; n must be factorable in four different ways. Example: $n = 24 = 2 \cdot 12 = 3 \cdot 8 = 4 \cdot 6 = 1 \cdot 24$

57a. $\frac{1 \text{ m}}{1 \text{ cm}} = 100$; $= 100^3 = (10^2)^3 = 10^6$

57b. $\frac{1 \text{ m}}{1 \text{ mm}} = 1000$; $= 1000^3 = (10^3)^3 = 10^9$

57c. $\frac{1 \text{ km}}{1 \text{ m}} = 1000$; $= 1000^3 = 10^9$

57d. $\frac{1 \text{ km}}{1 \text{ mm}} = 10^6$; $= (10^6)^3 = 10^{6 \cdot 3} = 10^{18}$

58a. $2^3 \cdot 2^{20} = 2^{3+20} = 2^{23}$ [bits] **58b.** $2^{10} \cdot 2^{20} = 2^{30}$ [bytes]; $2^3 \cdot 2^{30} = 2^{33}$ [bits] **59a.** $S = 4\pi r^2 = 4\pi(6.4 \times 10^6)^2 = 4\pi(6.4)^2 \cdot 10^{6 \cdot 2} \approx 514.7 \times 10^{12} \approx 5.15 \times 10^{14}$ [m^2] **59b.** $0.70 \cdot 5.15 \times 10^{14} \approx 3.6 \times 10^{14}$ [m^2]

59c. $3795 \cdot 3.6 \times 10^{14} \approx 13{,}662 \times 10^{14} \approx 1.37 \times 10^{18}$ [m^3]
60. **A.** $2^5 \cdot 2 = 32 \cdot 2 = 64$ **B.** $2^6 = 64$ **C.** $2^2 \cdot 2^3 = 2^{2+3} = 2^5 = 32$ **D.** $(2^3)^2 = 2^{3 \cdot 2} = 2^6 = 64$ **E.** $(2^2)(2^2)^2 = 2^2 \cdot 2^{2 \cdot 2} = 2^2 \cdot 2^4 = 2^6 = 64$; the answer is C. **61.** Add exponents for products of powers as in a^2a^4. Multiply exponents for powers of powers, as in $(a^2)^4$.

62.
$$5^6 = 25^x$$
$$5^6 = (5^2)^x$$
$$5^6 = 5^{2x}$$
$$6 = 2x$$
$$3 = x$$

63.
$$8^2 = 2^x$$
$$(2^3)^2 = 2^x$$
$$2^6 = 2^x$$
$$6 = x$$

64.
$$3^x = 27^4$$
$$3^x = (3^3)^4$$
$$3^x = 3^{12}$$
$$x = 12$$

65.
$$4^x = 2^6$$
$$(2^2)^x = 2^6$$
$$2^{2x} = 2^6$$
$$2x = 6$$
$$x = 3$$

66.
$$3^{2x} = 9^4$$
$$3^{2x} = (3^2)^4$$
$$3^{2x} = 3^8$$
$$2x = 8$$
$$x = 4$$

67.
$$2^x = \frac{1}{32}$$
$$2^x = \frac{1}{2^5}$$
$$2^x = 2^{-5}$$
$$x = -5$$

68. $(x^3)^4 = x^{12}$; $x^{34} = x^{81}$; no
69. The area $= \frac{1}{2}$ (base)(height) $= \frac{1}{2}(3x)(3x) = 4.5x^2$; the answer is B. **70.** $3(5.1 \times 10^{-5})^2 = 3 \cdot 5.1^2 \cdot 10^{-10} = 78.03 \times 10^{-10} = 7.803 \times 10^{-9}$; the answer is I.
71. $(7^{-2})^3 = 7^{-2 \cdot 3} = 7^{-6} = \frac{1}{7^6} = 0.0000085$; the answer is C. **72.** **H.** $25(n^3)^9 = 25n^{3 \cdot 9} = 25n^{27}$; the answer is H.
73. [2] No, $(x^2 + 3y)^2 \neq x^4 + 9y^2$; for $x = 2$, $y = 4$, $(x^2 + 3y)^2 = (4 + 12)^2 = 16^2 = 256$; $x^4 + 9y^2 = 2^4 + 9(4)^2 = 16 + 9 \cdot 16 = 160$ (OR equivalent explanation) [1] appropriate conclusion but no work to support conclusion
74. $bc^{-6} \cdot b = bbc^{-6} = \frac{b^2}{c^6}$ **75.** $(a^2b^3)(a^6) = a^2a^6b^3 = a^8b^3$ **76.** $9m^3(6m^2n^4) = 54m^5n^4$ **77.** $2t(-2t^4) = -4t^5$

78.
$$3x + 5 = -4x + 12$$
$$7x + 5 = 12$$
$$7x = 7$$
$$x = 1$$
$$y = 3 \cdot 1 + 5 = 8$$

79.
$$0.5x - 1 = 0.2x + 0.4$$
$$5x - 10 = 2x + 4$$
$$3x - 10 = 4$$
$$3x = 14$$
$$x = \frac{14}{3} = 4\frac{2}{3}$$
$$y = 0.5\left(\frac{14}{3}\right) - 1$$
$$y = \frac{7}{3} - 1 = \frac{4}{3} = 1\frac{1}{3}$$

80.
$$5x - 9 = 3x + 5$$
$$2x - 9 = 5$$
$$2x = 14$$
$$x = 7$$
$$y = 3 \cdot 7 + 5 = 26$$

81.
$$x + 4 = -5$$
$$x = -9$$
$$y = -5$$

82. Points are $(x_1, y_1), (x_2, y_2)$; slope $= \frac{y_2 - y_1}{x_2 - x_1} = \frac{0 - 3}{4 - 0} = -\frac{3}{4}$ **83.** slope $= \frac{1 - (-5)}{3 - 2} = 6$
84. $\frac{0 - 6}{1 - (-3)} = \frac{-6}{4} = -\frac{3}{2}$ **85.** $\frac{-9 - 0}{11 - 0} = -\frac{9}{11}$

CHECKPOINT QUIZ 1 *page 416*

1. $5^{-1}(3^{-2}) = \frac{1}{5 \cdot 3^2} = \frac{1}{5 \cdot 9} = \frac{1}{45}$ **2.** $(r^{-5})^{-4} = r^{-5(-4)} = r^{20}$ **3.** $(2x^5)(3x^{12}) = 2 \cdot 3x^{5+12} = 6x^{17}$
4. $\frac{mn^{-4}}{p^0q^{-2}} = \frac{mq^2}{n^4}$ **5.** $a^2b^0(a^{-3}) = a^{2-3} = \frac{1}{a}$
6. $(3^2)^{-1}(4m^2)^3 = 3^{-2} \cdot 4^3m^{2 \cdot 3} = \frac{64m^6}{9}$ **7.** $(2m^3)(3m^6) = 2 \cdot 3m^{3+6} = 6m^9$ **8.** $(3t^2)^3(2t^0)^{-3} = 3^3t^{2 \cdot 3}2^{-3} = \frac{27t^6}{8}$
9. $500 \cdot 2^0 = 500$; $500 \cdot 2^2 = 500 \cdot 4 = 2000$; $500 \cdot 2^5 = 500 \cdot 32 = 16{,}000$ **10a.** 6800 km $= 6.8 \times 10^3$ km
10b. radius $= 3.4 \times 10^3$ km; $S = 4\pi r^2 = 4\pi(3.4 \times 10^3)^2 = 4\pi(3.4)^2 \cdot 10^{3 \cdot 2} \approx 145 \times 10^6 = 1.45 \times 10^8$ [km^2]
10c. $1.45 \times 10^8 = 145{,}000{,}000$ [km^2]

8-5 Division Properties of Exponents *pages 417–423*

Check Skills You'll Need For complete solutions see *Daily Skills Check and Lesson Quiz Transparencies* or *Presentation Pro CD-ROM.*
1. $\frac{1}{4}$ **2.** 5 **3.** $\frac{3}{5}$ **4.** 31 **5.** $\frac{2}{5}$ **6.** $\frac{4}{15}$ **7.** $\frac{2}{7}$ **8.** $\frac{2}{7}$ **9.** $\frac{y}{3}$ **10.** $\frac{2y^2}{x}$ **11.** $\frac{c}{4}$ **12.** $\frac{4}{n^2}$

Check Understanding **1a.** $\frac{b^4}{b^9} = \frac{1}{b^{9-4}} = \frac{1}{b^5}$
1b. $\frac{z^{10}}{z^5} = z^{10-5} = z^5$ **1c.** $\frac{a^2b}{a^4b^3} = \frac{1}{a^{4-2}b^{3-1}} = \frac{1}{a^2b^2}$
1d. $\frac{m^{-1}n^2}{m^3n} = \frac{n^{2-1}}{m^{3+1}} = \frac{n}{m^4}$ **1e.** $\frac{x^2y^{-1}z^4}{xy^4z^{-3}} = \frac{x^{2-1}z^{4+3}}{y^{4+1}} = \frac{xz^7}{y^5}$
2a. $\frac{2 \times 10^3}{8 \times 10^8} = \frac{2}{8} \cdot 10^{3-8} = 0.25 \times 10^{-5} = 2.5 \times 10^{-6}$
2b. $\frac{7.5 \times 10^{12}}{2.5 \times 10^{-4}} = \frac{7.5}{2.5} \cdot 10^{12+4} = 3 \times 10^{16}$
2c. $\frac{4.2 \times 10^5}{12.6 \times 10^2} = \frac{4.2}{12.6} \cdot 10^{5-2} = \frac{1}{3} \times 10^3 = 3.\overline{3} \times 10^2$
2d. $\frac{3.2 \text{ million}}{270.5 \text{ million}} = 0.0118 = 1.18 \times 10^{-2}$ [tons per person]
3a. $\left(\frac{3}{x^2}\right)^2 = \frac{3^2}{(x^2)^2} = \frac{9}{x^4}$ **3b.** $\left(\frac{x}{y^2}\right)^3 = \frac{x^3}{(y^2)^3} = \frac{x^3}{y^{2 \cdot 3}} = \frac{x^3}{y^6}$
3c. $\left(\frac{t^7}{2^3}\right)^2 = \frac{(t^7)^2}{(2^3)^2} = \frac{t^{7 \cdot 2}}{8^2} = \frac{t^{14}}{64}$ **4a.** $\left(\frac{3}{4}\right)^{-3} = \frac{4^3}{3^3} = \frac{64}{27}$

4b. $\left(\frac{-1}{2}\right)^{-5} = \frac{2^5}{(-1)^5} = \frac{32}{-1} = -32$

4c. $\left(\frac{2r}{s}\right)^{-1} = \frac{s^1}{(2r)^1} = \frac{s}{2r}$ **4d.** $\left(\frac{7a}{m}\right)^{-2} = \frac{m^2}{(7a)^2} = \frac{m^2}{49a^2}$

Exercises **1.** $\frac{5^9}{5^2} = 5^7$ **2.** $\frac{2^4}{2^3} = 2^1$ **3.** $\frac{3^2}{3^5} = 3^{-3}$ **4.** $\frac{5^2 5^3}{5^3 5^2} = 5^0$

5. $\frac{2^5}{2^7} = \frac{1}{2^{7-5}} = \frac{1}{2^2} = \frac{1}{4}$ **6.** $\frac{2^7}{2^5} = 2^2 = 4$ **7.** $\frac{c^{12}}{c^{15}} = \frac{1}{c^{15-12}} = \frac{1}{c^3}$

8. $\frac{m^{-2}}{m^{-5}} = m^{-2+5} = m^3$ **9.** $\frac{3s^{-9}}{6s^{-11}} = \frac{s^{-9+11}}{2} = \frac{s^2}{2}$

10. $\frac{x^{13}y^2}{x^{13}y} = y$ **11.** $\frac{c^2d^{-3}}{c^3d^{-1}} = \frac{1}{c^{3-2}d^{-1+3}} = \frac{1}{cd^2}$ **12.** $\frac{3^2m^3t^6}{3^5m^7t^{-5}} = \frac{t^{6+5}}{3^{5-2}m^{7-3}} = \frac{t^{11}}{3^3m^4} = \frac{t^{11}}{27m^4}$ **13.** $\frac{6.5 \times 10^{15}}{1.3 \times 10^8} = \frac{6.5}{1.3} \cdot 10^{15-8} = 5 \times 10^7$ **14.** $\frac{2.7 \times 10^{-8}}{9 \times 10^{-4}} = \frac{2.7}{9} \cdot 10^{-8+4} = 0.3 \times 10^{-4} = 3 \times 10^{-5}$ **15.** $\frac{4.2 \times 10^8}{7 \times 10^5} = \frac{4.2}{7} \cdot 10^{8-5} = 0.6 \times 10^3 = 6 \times 10^2$ **16.** $\frac{8.4 \times 10^{-5}}{2 \times 10^{-8}} = \frac{8.4}{2} \cdot 10^{-5+8} = 4.2 \times 10^3$

17. $\frac{4.65 \times 10^{-4}}{3.1 \times 10^2} = \frac{4.65}{3.1} \cdot 10^{-4-2} = 1.5 \times 10^{-6}$

18. $\frac{3.5 \times 10^6}{5 \times 10^8} = \frac{3.5}{5} \cdot 10^{6-8} = 0.7 \times 10^{-2} = 7 \times 10^{-3}$

19a. 386 billion $= 386 \times 10^9 = 3.86 \times 10^{11}$ [hours]; 265 million $= 265 \times 10^6 = 2.65 \times 10^8$ [people]

19b. $\frac{3.86 \times 10^{11}}{2.65 \times 10^8} = \frac{3.86}{2.65} \cdot 10^{11-8} \approx 1.457 \times 10^3 = 1457$ [hours] **19c.** $\frac{1457}{365} \approx 4.0$ hours **20.** $\frac{3600 \frac{\text{seconds}}{\text{hour}}}{3.6 \times 10^{15} \frac{\text{picoseconds}}{\text{hour}}} = 1000 \times 10^{-15} \frac{\text{s}}{\text{ps}} = 1 \times 10^{-12} \frac{\text{seconds}}{\text{picosecond}}$ **21.** $\left(\frac{3}{5}\right)^2 = \frac{3^2}{5^2} = \frac{9}{25}$ **22.** $\left(\frac{1}{x}\right)^3 = \frac{1^3}{x^3} = \frac{1}{x^3}$ **23.** $\left(\frac{2x^5}{y}\right)^5 = \frac{(2x)^5}{y^5} = \frac{2^5x^5}{y^5} = \frac{32x^5}{y^5}$ **24.** $\left(\frac{3a}{2b}\right)^4 = \frac{(3a)^4}{(2b)^4} = \frac{3^4a^4}{2^4b^4} = \frac{81a^4}{16b^4}$ **25.** $\left(\frac{2^2}{5}\right)^3 = \left(\frac{4}{5}\right)^3 \frac{4^3}{5^3} = \frac{64}{125}$ **26.** $\left(\frac{3^3}{3^4}\right)^2 = \left(\frac{1}{3^{4-3}}\right)^2 = \left(\frac{1}{3}\right)^2 = \frac{1}{3^2} = \frac{1}{9}$

27. $\left(\frac{6}{n^6}\right)^2 = \frac{6^2}{(n^6)^2} = \frac{36}{n^{6 \cdot 2}} = \frac{36}{n^{12}}$

28. $\left(\frac{2p}{5}\right)^3 = \frac{(2p)^3}{5^3} = \frac{2^3p^3}{125} = \frac{8p^3}{125}$ **29.** $\left(\frac{2}{3}\right)^{-1} = \frac{3}{2}$

30. $\left(\frac{2}{3}\right)^{-2} = \left(\frac{3}{2}\right)^2 = \frac{3^2}{2^2} = \frac{9}{4}$ **31.** $\left(-\frac{2}{3}\right)^{-2} = \left(-\frac{3}{2}\right)^2 = \left(\frac{-3}{2}\right)^2 = \frac{(-3)^2}{2^2} = \frac{9}{4}$ **32.** $\left(-\frac{2}{3}\right)^{-3} = \left(-\frac{3}{2}\right)^3 = \left(\frac{-3}{2}\right)^3 = \frac{(-3)^3}{2^3} = \frac{-27}{8} = -\frac{27}{8}$ **33.** $\left(\frac{3x^4}{15}\right)^2 = \left(\frac{x^4}{5}\right)^2 = \frac{(x^4)^2}{5^2} = \frac{x^{4 \cdot 2}}{25} = \frac{x^8}{25}$ **34.** $\left(\frac{4n}{2n^2}\right)^3 = \left(\frac{2}{n}\right)^3 = \frac{2^3}{n^3} = \frac{8}{n^3}$ **35.** $\left(\frac{c^5}{c^9}\right)^3 = \left(\frac{1}{c^4}\right)^3 = \frac{1}{(c^4)^3} = \frac{1}{c^{4 \cdot 3}} = \frac{1}{c^{12}}$ **36.** $\left(\frac{3b^2}{5}\right)^0 = 1$ **37.** 5^3 simplifies to 125; $5^3m^3 = 125m^3$. **38.** y^{-2} contains a negative exponent; $x^5y^{-2} = \frac{x^5}{y^2}$. **39.** Each factor should be raised to the 4th power and simplified; $(2c)^4 = 16c^4$. **40.** x^0 simplifies to 1; $x^0y = y$. **41.** The base d should appear only once; $\frac{d^7}{d} = d^6$. **42.** $\frac{3^2 \cdot 5^0}{2^3} = \frac{9}{8}$ **43.** $\left(\frac{2m^5}{m^2}\right)^{-4} = (2m^3)^{-4} = \frac{1}{(2m^3)^4} = \frac{1}{2^4(m^3)^4} = \frac{1}{16m^{3 \cdot 4}} = \frac{1}{16m^{12}}$

44. $\frac{5x^3}{(5x)^3} = \frac{5x^3}{5^3x^3} = \frac{1}{5^{3-1}} = \frac{1}{5^2} = \frac{1}{25}$ **45.** $\frac{(2a^7)(3a^2)}{6a^3} = a^{7+2-3} = a^6$ **46.** $\left(\frac{7t^3}{21t}\right)^3 = \left(\frac{t^2}{3}\right)^3 = \frac{(t^2)^3}{3^3} = \frac{t^6}{27}$

47. $\left(\frac{n^4n}{n^{-2}}\right)^{-4} = (n^7)^{-4} = \frac{1}{(n^7)^4} = \frac{1}{n^{28}}$

48. $\left(\frac{2k^3}{3k^{-2}}\right)^{-2} = \left(\frac{2k^5}{3}\right)^{-2} = \left(\frac{3}{2k^5}\right)^2 = \frac{3^2}{(2k^5)^2} = \frac{9}{2^2(k^5)^2} = \frac{9}{4k^{10}}$ **49.** $\frac{7^9 \cdot (1^0)^2}{7^7} = 7^2 \cdot 1^2 = 49$ **50a.** 94.7 million $= 94.7 \times 10^6 = 9.47 \times 10^7$ [households]; 544 billion $= 544 \times 10^9 = 5.44 \times 10^{11}$ [local calls]; 97 billion $= 97 \times 10^9 = 9.7 \times 10^{10}$ [long-distance calls]

50b. $\frac{\text{local calls}}{\text{households}} = \frac{5.44 \times 10^{11}}{9.74 \times 10^7} = \frac{5.44}{9.74} \cdot 10^{11-7} \approx 0.5585 \times 10^4 = 5585$ [local calls per household]

50c. $\frac{\text{long-distance calls}}{\text{households}} = \frac{9.7 \times 10^{10}}{9.74 \times 10^7} = \frac{9.7}{9.74} \cdot 10^{10-7} \approx 0.996 \times 10^3 = 996$ [long-distance calls per household]

51a. $\frac{a^m}{a^n} = a^{m-n} = a^{-(n-m)} = \frac{1}{a^{n-m}}$

51b. Check students' work.

52. $\left(\frac{2ab^6}{a^3b}\right)^{-2} = \left(\frac{2b^{6-1}}{a^{3-1}}\right)^{-2} = \left(\frac{2b^5}{a^2}\right)^{-2} = \frac{(a^2)^2}{(2b^5)^2} = \frac{a^{2 \cdot 2}}{2^2b^{5 \cdot 2}} = \frac{a^4}{4b^{10}}$ **53.** $\frac{a^3b^2c^{-4}}{a^{-2}b^5c^{-9}} = \frac{a^{3+2}c^{-4+9}}{b^{5-2}} = \frac{a^5c^5}{b^3}$

54. $\frac{\left(\frac{1}{3}\right)^{-3}}{\left(\frac{1}{6}\right)^{-2}} = \frac{3^3}{6^2} = \frac{3^3}{(2 \cdot 3)^2} = \frac{3^3}{2^2 \cdot 3^2} = \frac{3}{2^2} = \frac{3}{4}$

55. $\frac{0.2^2 \cdot 0.2^3}{0.2^6} = \frac{1}{0.2^1} = 5$ **56.** $\left(\frac{p^{-2}q^4r}{p^3q^5}\right)^5 = \left(\frac{r}{p^5q}\right)^5 = \frac{r^5}{p^{25}q^5}$

57. $\left(\frac{(-3)^2}{(-2)^{-4}1}\right)^2 = [9 \cdot (-2)^4]^2 = (9 \cdot 16)^2 = 144^2 = 20{,}736$ **58.** $\left(\frac{(3x)^2y}{x^2y^4}\right)^{-2} = \left(\frac{9x^2y}{x^2y^4}\right)^{-2} = \left(\frac{9}{y^3}\right)^{-2} = \left(\frac{y^3}{9}\right)^2 = \frac{y^6}{81}$ **59.** $\frac{(5a^2)(6b^3)}{(2a^3)(25b^{-2})} = \frac{3b^5}{25a}$ **60a.** $\frac{\text{centenarians}}{\text{total}} = \frac{6.5 \times 10^4}{2.81 \times 10^8} = \frac{6.5}{2.81} \cdot 10^{-4} \approx 2.3 \times 10^4 = 0.00023 = 0.023\%$

60b. $\frac{\text{noncentenarians}}{\text{total}} = \frac{(2.81 \times 10^8) - (6.5 \times 10^4)}{2.81 \times 10^8} = \frac{(2.81 \times 10^8) - (0.00065 \times 10^8)}{2.81 \times 10^8} = \frac{(2.81) - (0.00065)}{2.81} = \frac{2.80935}{2.81} \approx 0.99977 \approx 99.98\%$ **61.** Jared simplified first inside the parentheses, and then squared the result. Lena squared the numerator and denominator, and then simplified. **62a.** $\frac{\text{debt}}{\text{people}}$; $\frac{3.23 \times 10^{12}}{2.487 \times 10^8} = \frac{3.23}{2.487} \times 10^{12-8} \approx 1.2988 \times 10^4$; about \$12,988 per person **62b.** $\frac{5.66 \times 10^{12}}{2.73 \times 10^8} = 2.0733 \times 10^4$; about \$20,733 per person

62c. $\frac{20{,}733 - 12{,}988}{12{,}988} = \frac{7745}{12{,}988} \approx 0.596 \approx 60\%$

63a. The student treated $\frac{5^4}{5}$ as $\left(\frac{5}{5}\right)^4$.

63b. $\frac{5^4}{5} = \frac{5^4}{5^1} = 5^{4-1} = 5^3 = 125$ **64.** $\frac{3^5}{5^5} = \left(\frac{3}{5}\right)^5$

65. $\frac{m^7}{n^7} = \left(\frac{m}{n}\right)^7$ **66.** $\frac{d^8}{d^5} = d^{8-5} = d^3$ **67.** $\frac{10^7 \cdot 10^0}{10^{-3}} = 10^{7+3} = 10^{10}$ **68.** $\frac{27x^3}{8y^3} = \frac{3^3x^3}{2^3y^3} = \left(\frac{3x}{2y}\right)^3$

69. $\frac{4m^2}{169m^4} = \frac{4}{169m^2} = \frac{2^2}{13^2m^2} = \left(\frac{2}{13m}\right)^2$

70. $\frac{49m^2}{25n^2} = \left(\frac{7m}{5n}\right)^2$ **71.** $\frac{125c^7}{216c^4} = \frac{5^3c^3}{6^3} = \left(\frac{5c}{6}\right)^3$

72a. $\frac{2.4 \times 10^{12} \text{ cells}}{2 \times 10^6 \frac{\text{cells}}{\text{second}}} = \frac{2.4}{2} \cdot 10^6 \text{ seconds} = 1.2 \times 10^6 \text{ seconds}$ **72b.** $\left(1.2 \times 10^6 \text{ s}\right)\left(\frac{1 \text{ h}}{3600 \text{ s}}\right)\left(\frac{1 \text{ day}}{24 \text{ h}}\right) \approx 13.9 \text{ days}$ **73a,b.** Check students' work. **73c.** No. $\frac{x \times 10^n}{2} = \frac{x}{2} \times 10^n$. In scientific notation, the exponent of 10 remains unchanged if $\frac{x}{2} \geq 1$; the exponent of 10 is reduced by 1 if $\frac{x}{2} < 1$. **74.** $2^{-3} = \frac{1}{2^3}$; definition of negative exponent **75.** $\frac{2^2}{2^5} = \frac{1}{2^3}$; dividing powers with the same base **76.** $\left(\frac{1}{2}\right)^3 = \frac{1}{2^3}$; raising a quotient to a power

77. $\frac{1}{2^{-4}2^7} = \frac{1}{2^3}$; multiplying powers with the same base

78. $\frac{(2^4)^3}{2^{15}} = \frac{2^{4 \cdot 3}}{2^{15}} = \frac{2^{12}}{2^{15}} = \frac{1}{2^{15-12}} = \frac{1}{2^3} = \frac{1}{8}$; raising a power to a power; dividing powers with the same base

79. $n^{x+2} \div n^x = \frac{n^{x+2}}{n^x} = n^{x+2-x} = n^2$ **80.** $n^{5x} \div n^x = \frac{n^{5x}}{n^x} = n^{5x-x} = n^{4x}$ **81.** $\left(\frac{x^m}{x^{m-2}}\right)^2 = [x^{m-(m-2)}]^2 = (x^2)^2 = x^{2 \cdot 2} = x^4$ **82.** $\frac{\left(\frac{n^5}{n^4}\right)}{n^3} = \frac{n^{5-4}}{n^3} = \frac{n}{n^3} = \frac{1}{n^{3-1}} = \frac{1}{n^2}$

83a.

Distance From the Sun (kilometers)

Planet	Maximum : Minimum
Mercury	$6.97 \times 10^7 : 4.59 \times 10^7 \approx 1.52$
Venus	$1.089 \times 10^8 : 1.075 \times 10^8 \approx 1.01$
Earth	$1.521 \times 10^8 : 1.471 \times 10^8 \approx 1.03$
Mars	$2.491 \times 10^8 : 2.067 \times 10^8 \approx 1.21$
Jupiter	$8.157 \times 10^8 : 7.409 \times 10^8 \approx 1.10$
Saturn	$1.507 \times 10^9 : 1.347 \times 10^9 \approx 1.12$
Uranus	$3.004 \times 10^9 : 2.735 \times 10^9 \approx 1.10$
Neptune	$4.537 \times 10^9 : 4.457 \times 10^9 \approx 1.02$
Pluto	$7.375 \times 10^9 : 4.425 \times 10^9 \approx 1.67$

83b. A perfectly circular orbit would have a $\frac{\text{maximum}}{\text{minimum}}$ ratio of 1. The greater the ratio, the more elongated (egg-shaped, or elliptical) the orbit. **83c.** Pluto has the least circular orbit; Venus's orbit is closest to a circle.

84. $\frac{(-6)^5}{6^5} = \frac{-(6)^5}{6^5} = -1$; the answer is B.

85. $\frac{-5x^3y^5}{15x^{-7}y^5z^{-2}} = \frac{-x^{10}z^2}{3} = \frac{-(-1)^{10}3^2}{3} = -3$; the answer is G.

86. $2^{-1} = 0.5$; the answer is D. **87. A.** $\left(-\frac{7}{5}\right)^{-3} = \left(-\frac{5}{7}\right)^{-3}$ = negative **B.** Positive; the answer is B.

88. A. $\left(\frac{-1}{2^2}\right)^{-2} = \left(\frac{2^2}{-1}\right)^2$ = same as B; the answer is C.

89. A. $\left(\frac{2 \cdot 5}{10^2}\right)^2 = \left(\frac{10}{10^2}\right)^2 = \left(\frac{1}{10}\right)^2 = \frac{1}{10^2}$

B. $\left(\frac{2 \cdot 10}{5^2}\right)^{-2} = \left(\frac{2 \cdot 2 \cdot 5}{5 \cdot 5}\right)^{-2} = \left(\frac{4}{5}\right)^{-2} = \left(\frac{5}{4}\right)^2 = 1.25^2$; the answer is B. **90.** [4] $\frac{7.43 \times 10^8 \text{ miles}}{2.5 \times 10^4 \frac{\text{miles}}{\text{hour}}} = 2.972 \times 10^4 \text{ hours} \approx 30{,}000 \text{ hours}$;

$30{,}000 \text{ hours} \cdot \frac{1 \text{ day}}{24 \text{ hours}} \cdot \frac{1 \text{ year}}{365 \text{ days}} \approx 3.4 \text{ years}$

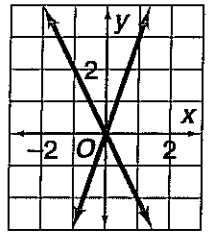
[3] one computational error [2] missing or incorrect conversion factor [1] no work shown

91. $(3y^2)^3 = 3^3(y^2)^3 = 27(y^{2 \cdot 3}) = 27y^6$ **92.** $(2m^{-7})^3 = 2^3\left(\frac{1}{m^7}\right)^3 = \frac{8}{m^{7 \cdot 3}} = \frac{8}{m^{21}}$ **93.** $(r^2t^{-5})^{-4} = \left(\frac{r^2}{t^5}\right)^{-4} = \left(\frac{t^5}{r^2}\right)^4 = \frac{t^{20}}{r^8}$ **94.** $2(3s^{-2})^{-3} = 2\left(\frac{3}{s^2}\right)^{-3} = 2\left(\frac{s^2}{3}\right)^3 = \frac{2s^6}{27}$

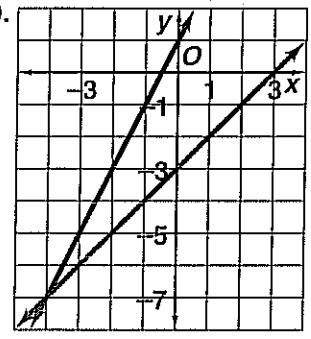
95. $(2^3c^{2-1}) = \frac{1}{2^3c^2} = \frac{1}{8c^2}$ **96.** $(-3)^2(-r^3)^2 = 9r^{3 \cdot 2} = 9r^6$

97. $(7^0n^{-3})^2(n^5)^2 = n^{-6}n^{10} = n^4$ **98.** $(7^2y^{12})^0 = 1$

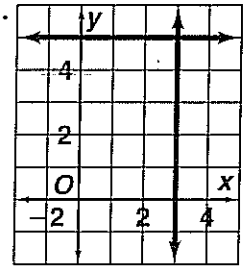
99. (0, 0)



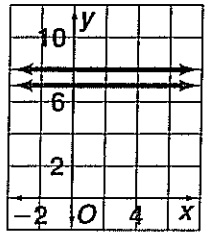
100. (−4, −7)



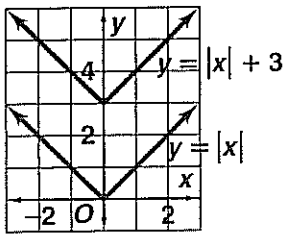
101. (3, 5)



102. no solution



103.



8-6 Geometric Sequences

pages 424–429

Check Skills You'll Need For complete solutions see *Daily Skills Check and Lesson Quiz Transparencies* or *Presentation Pro CD-ROM.*

1. 2 **2.** −2 **3.** −1.2 **4.** 3.5 **5.** 32, 64 **6.** 108, 324 **7.** 3.2, 6.4 **8.** 12.5, 6.25

Check Understanding **1a.** $\frac{150}{750} = \frac{1}{5}; \frac{6}{30} = \frac{1}{5}$ **1b.** $\frac{-6}{-3} = 2$; $\frac{-24}{-12} = 2$ **1c.** $\frac{6}{4} = \frac{3}{2}; \frac{13.5}{9} = \frac{3}{2}$ **2a.** common ratio = 3; $3 \cdot 27 = 81; 3 \cdot 81 = 243; 3 \cdot 243 = 729$ **2b.** common ratio = −0.5; $-0.5(-15) = 7.5; -0.5 \cdot 7.5 = -3.75; -0.5(-3.75) = 1.875$ **2c.** common ratio = 2; $2 \cdot 8.8 = 17.6; 2 \cdot 17.6 = 35.2; 2 \cdot 35.2 = 70.4$ **3a.** differences = 2, 2, 2; arithmetic **3b.** ratios = 2, 2, 2; geometric **3c.** differences = 2, 2, 2: arithmetic **4a.** $A(1) = 4 \cdot 3^{1-1} = 4 \cdot 1 = 4; A(6) = 4 \cdot 3^{6-1} = 4 \cdot 3^5 = 972; A(12) = 4 \cdot 3^{12-1} = 4 \cdot 3^{11} = 708{,}588$ **4b.** $A(1) = -2 \cdot 5^{1-1} = -2 \cdot 1 = -2; A(6) = -2 \cdot 5^{6-1} = -2 \cdot 5^5 = -6250; A(12) = -2 \cdot 5^{12-1} = -2 \cdot 5^{11} = -97{,}656{,}250$ **5.** $A(n) = 200 \cdot (0.56)^{n-1}; A(3) = 200 \cdot 0.56^{4-1} = 200 \cdot 0.56^3 \approx 35.1$ [cm]

Exercises **1.** $\frac{8}{2} = 4$ **2.** $\frac{-12}{-3} = 4$ **3.** 0.1 **4.** 2.5 **5.** −0.25 **6.** 2 **7.** 40, 80, 160 **8.** 48, 96, 192 **9.** 20.25, 30.375, 45.5625 **10.** −0.5, 0.25, −0.125 **11.** 0.36, 0.072, 0.0144 **12.** −48, 96, −192 **13.** geometric; common ratio = 7 **14.** arithmetic; common difference = −4 **15.** geometric; common ratio = $-\frac{4}{3}$ **16.** arithmetic; common difference = −5 **17.** arithmetic; common difference = 0.7 **18.** geometric; common ratio = $\frac{4}{3}$ **19.** $A(1) = 5 \cdot 3^{1-1} = 5 \cdot 3^0 = 5 \cdot 1 = 5; A(4) = 5 \cdot 3^{4-1} = 5 \cdot 3^3 = 5 \cdot 27 = 135; A(8) = 5 \cdot 3^{8-1} = 5 \cdot 3^7 = 5 \cdot 2187 = 10{,}935$ **20.** $A(1) = -5 \cdot 3^{1-1} = -5 \cdot 3^0 = -5 \cdot 1 = -5; A(4) = -5 \cdot 3^{4-1} = -5 \cdot 3^3 = -5 \cdot 27 = -135; A(8) = -5 \cdot 3^{8-1} = -5 \cdot 3^7 = -5 \cdot 2187 = -10{,}935$ **21.** $A(1) = 5 \cdot (-3)^{1-1} = 5 \cdot (-3)^0 = 5; A(4) = 5 \cdot (-3)^{4-1} = 5 \cdot (-3)^3 = 5(-27) = -135; A(8) = 5 \cdot (-3)^{8-1} = 5 \cdot (-3)^7 = 5(-2187) = -10{,}935$ **22.** $A(1) = 0.5 \cdot 3^{1-1} = 0.5 \cdot 3^0 = 0.5; A(4) = 0.5 \cdot 3^{4-1} = 0.5 \cdot 3^3 = 0.5 \cdot 27 = 13.5; A(8) = 0.5 \cdot 3^{8-1} = 0.5 \cdot 3^7 = 0.5 \cdot 2187 = 1093.5$ **23.** $A(1) = -2 \cdot 5^{1-1} = -2 \cdot 5^0 = -2 \cdot 1 = -2; A(4) = -2 \cdot 5^{4-1} = -2 \cdot 5^3 = -2 \cdot 125 = -250; A(8) = -2 \cdot 5^{8-1} = -2 \cdot 5^7 = -2 \cdot 78{,}125 = -156{,}250$ **24.** $A(1) = -1.1 \cdot (-4)^{1-1} = -1.1 \cdot (-4)^0 = -1.1; A(4) = -1.1 \cdot (-4)^{4-1} = -1.1 \cdot (-4)^3 = -1.1(-64) = 70.4; A(8) = -1.1 \cdot (-4)^{8-1} = -1.1(-16{,}384) = 18{,}022.4$ **25.** $A(n) = 6 \cdot 0.5^{n-1}; A(5) = 6 \cdot 0.5^{5-1} = 6 \cdot 0.5^4 = 0.375$ **26.** $A(n) = -6 \cdot 2^{n-1}; A(10) = -6 \cdot 2^{10-1} = -6 \cdot 2^9 = -3072$ **27.** $A(n) = 7 \cdot 1.1^{n-1}; A(4) = 7 \cdot 1.1^{4-1} = 7 \cdot 1.1^3 = 9.317$ **28.** $A(n) = 1 \cdot (-4)^{n-1}; A(7) = (-4)^{7-1} = (-4)^6 = 4096$ **29a.** $A(n) = 100 \cdot (0.64)^{n-1}$ **29b.** $A(6) = 100 \cdot 0.64^{6-1} = 100 \cdot 0.64^5 \approx 10.74$; about 10.74 cm **30.** $\frac{8}{3}, \frac{8}{9}, \frac{8}{27}; A(n) = 216 \cdot \left(\frac{1}{3}\right)^{n-1}$ **31.** 1, 0.2, 0.04; $A(n) = 625 \cdot (0.2)^{n-1}$ **32.** 656.1, 5904.9, 53,144.1; $A(n) = 0.1 \cdot 9^{n-1}$ **33.** 1, −0.5, 0.25; $A(n) = 16 \cdot (-0.5)^{n-1}$ **34.** Check students' work. **35.** If all consecutive terms have a common difference, the sequence is arithmetic. If all consecutive terms have a common ratio, the sequence is geometric.

36a.

Number of Folds	Number of Rectangles
0	1
1	2
2	4
3	8
4	16
5	32

36b. $A(n) = 2 \cdot 2^{n-1} = 1 \cdot 2^n$ **36c.** $A(10) = 2^{10} = 1024$; 1024 rectangles **37.** arithmetic; 3, 1, −1 **38.** neither; −3, −8, −14 **39.** geometric; 1.125, 0.5625, 0.28125 **40.** arithmetic; 20, 22, 24 **41a.** $A(n) = 36 \cdot (0.9)^{n-1}$ **41b.** 6; $n = 1$ corresponds to the first swing, because $A(1) = 36$. **41c.** $A(6) = 36 \cdot (0.9)^{6-1} = 36 \cdot (0.9)^5 \approx 21.3$ [cm] **42a.** $\frac{1}{2}, \frac{1}{4}, \frac{1}{8}, \frac{1}{16}$ **42b.** $2^{-1}, 2^{-2}, 2^{-3}, 2^{-4}$ **42c.** $r = 2^{-n}$ **42d.** 2^{-10} or $\frac{1}{2^{10}}$ **43.** No; if one term were 0, then all terms would be 0. Terms are $A(n) = a \cdot r^{n-1}$; we can have $A = 0$ only if a or $r = 0$; then all A's = 0. **44a.** $1, \frac{3}{4}, \frac{9}{16}, \frac{27}{64}$ **44b.** $r(n) = 1 \cdot \left(\frac{3}{4}\right)^{n-1}$ **44c.** $r(6) = \left(\frac{3}{4}\right)^{6-1} = \left(\frac{3}{4}\right)^5 = \frac{3^5}{4^5} = \frac{243}{1024}$ **44d.** $0, \frac{1}{4}, \frac{7}{16}, \frac{37}{64}$ **44e.** $r_{\text{not shaded}} = 1 - r_{\text{shaded}} = 1 - 1 \cdot \left(\frac{3}{4}\right)^{n-1}$ **44f.** $r_{\text{not shaded}} = 1 - \left(\frac{3}{4}\right)^{8-1} = 1 - \left(\frac{3}{4}\right)^7 = 1 - \frac{3^7}{4^7} = 1 - \frac{2187}{16{,}384} = \frac{14{,}197}{16{,}384}$ **45.** $x; x^5, x^6, x^7$ **46.** $3x; 27x^4, 81x^5, 243x^6$ **47.** $xy^2; x^5y^9, x^6y^{11}, x^7y^{13}$ **48.** $ab; 2a^4b^2, 2a^5b^3, 2a^6b^4$ **49.** 0.06; 2.592×10^2, 1.5552×10^1, 9.3312×10^{-1}

50.
$$A(n) = 2 \cdot 4^{n-1} = 512$$
$$4^{n-1} = 256$$
$$4^{n-1} = 4^4$$
$$n - 1 = 4$$
$$n = 5$$

The fifth term is 512.

51. The answer is D. **52.** Number of cans in each tier = 1, 4, 9, 16, 25, 36; total number of cans in display = 1, 5, 14, 30, 55, 91; the answer is H. **53.** The answer is B. **54.** [2] $A(n) = 350 \cdot 2^{n-1}; A(1) = 350$ ✓; $A(5) = 350 \cdot 2^{5-1} = 350 \cdot 2^4 = 5600$; 5600 bacteria
[1] no work shown

55. $\left(\frac{a^2}{a^3}\right)^{-4} = \left(\frac{1}{a}\right)^{-4} = a^4$ **56.** $\left(\frac{1}{2}\right)^{-4} = 2^4 = 16$

57. $\left(\frac{x^2z}{z^{-3}}\right)^{-5} = (x^2z^4)^{-5} = \left(\frac{1}{x^2z^4}\right)^5 = \frac{1}{x^{10}z^{20}}$ **58.** $\left(\frac{m^{-3}}{n^4}\right)^0 = 1$ **59.** $\left(\frac{8}{9}\right)^{-2} = \left(\frac{9}{8}\right)^2 = \frac{9^2}{8^2} = \frac{81}{64}$ **60.** $\left(\frac{m^4}{m^2}\right)^{-7} = (m^2)^{-7} = \left(\frac{1}{m^2}\right)^7 = \frac{1}{m^{14}}$ **61.** $\left(\frac{pq^0}{p^4}\right)^5 = \left(\frac{1}{p^3}\right)^5 = \frac{1}{p^{15}}$

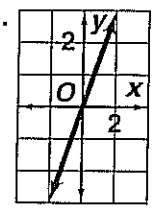
62. $\left(\frac{c^2d^{-2}}{d^3}\right)^{-1} = \left(\frac{c^2}{d^5}\right)^{-1} = \frac{d^5}{c^2}$ **63.** $0.002467 = 2.467 \times 10^{-3}$ **64.** 1×10^6 acre-ft $\cdot\ 3.26 \times 10^5 \frac{\text{gal}}{\text{acre-ft}} = 3.26 \times 10^{11}$ gal **65.** $y = \frac{8}{3}x$ **66.** $y = \frac{-2}{5}x = -\frac{2}{5}x$ **67.** $y = \frac{-7}{6}x = -\frac{7}{6}x$ **68.** $y = \frac{-5}{-3}x = \frac{5}{3}x$ **69.** $y = \frac{7}{4}x$ **70.** $y = \frac{4}{-16}x = -\frac{1}{4}x$ **71.** $y = \frac{5}{9}x$ **72.** $y = \frac{-2}{4}x = -\frac{1}{2}x$

8-7 Exponential Functions

pages 430–436

Check Skills You'll Need For complete solutions see *Daily Skills Check and Lesson Quiz Transparencies* or *Presentation Pro CD-ROM.*

1.



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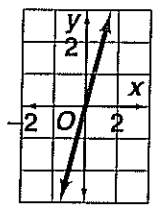

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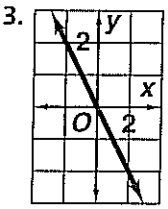
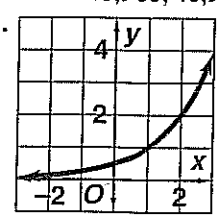


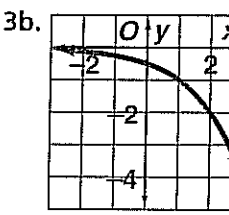
4. 9 **5.** $\frac{1}{125}$ **6.** 162 **7.** $\frac{2}{9}$ **8.** $\frac{3}{2}$ **9.** 90

Check Understanding **1a.** $y(x) = 4^x$; $y(-2) = 4^{-2} = \frac{1}{4^2} = \frac{1}{16}$; $y(0) = 4^0 = 1$; $y(3) = 4^3 = 64$ **1b.** $f(-2) = 10 \cdot 5^{-2} = \frac{10}{5^2} = \frac{2}{5}$; $f(0) = 10 \cdot 5^0 = 10$; $f(3) = 10 \cdot 5^3 = 1250$ **1c.** $g(-2) = -2 \cdot 3^{-2} = \frac{-2}{3^2} = -\frac{2}{9}$; $g(0) = -2 \cdot 3^0 = -2$; $g(3) = -2 \cdot 3^3 = -54$ **2.** $f(6) = 10 \cdot 4^6 = 40{,}960$; 40,960 animals

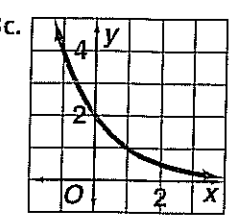
3a.



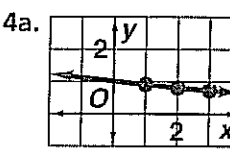
3b.



3c.



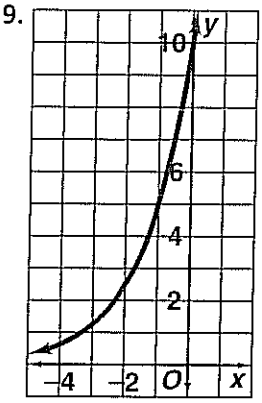
4a.



4b. Since $f(0) = (1.5)^0 = 1$, this represents copies being made at the same size as the original, or at 100%.

Exercises **1.** $f(x) = 6^x$; $f(3) = 6^3 = 216$ **2.** $g(-2) = 2 \cdot 3^{-2} = \frac{2}{3^2} = \frac{2}{9}$ **3.** $20 \cdot (0.5)^3 = 2.5$ **4.** $0.5 \cdot 4^3 = 32$ **5.** $50 \cdot (0.3)^2 = 4.5$ **6.** $1.8 \cdot 2^6 = 115.2$ **7.** $100 \cdot \left(\frac{1}{2}\right)^{-4} = 100 \cdot 2^4 = 1600$ **8.** $9 \cdot \left(\frac{5}{2}\right)^{-3} = 9 \cdot \left(\frac{2}{5}\right)^3 = 0.576$ **9.** $f(x) = 10{,}000 \cdot 2^{\frac{x}{13}}$; $f(52) = 10{,}000 \cdot 2^{\frac{52}{13}} = 10{,}000 \cdot 2^4 = 160{,}000$ [$]; $f(65) = 10{,}000 \cdot 2^{\frac{65}{13}} = 10{,}000 \cdot 2^5 = 320{,}000$ [$] **10.** $f(x) = 500 \cdot 2^{\frac{x}{15}}$; $f(30) = 500 \cdot 2^{\frac{30}{15}} = 500 \cdot 2^2 = 2000$ [$]; $f(45) = 500 \cdot 2^{\frac{45}{15}} = 500 \cdot 2^3 = 4000$ [$] **11.** $f(x) = 2000 \cdot 2^{\frac{x}{8}}$; $f(24) = 2000 \cdot 2^{\frac{24}{8}} = 2000 \cdot 2^3 = 16{,}000$ [$]; $f(32) = 2000 \cdot 2^{\frac{32}{8}} = 2000 \cdot 2^4 = 32{,}000$ [$] **12.** A **13.** C **14.** B **15.** B **16.** D **17.** C **18.** A

19.



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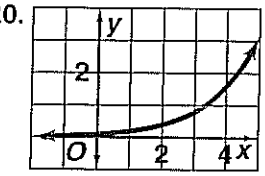
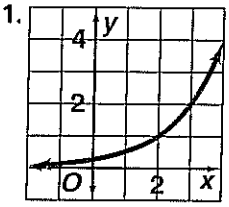
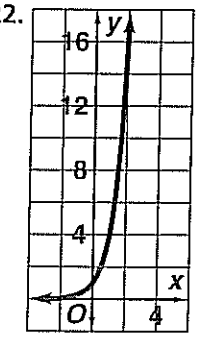


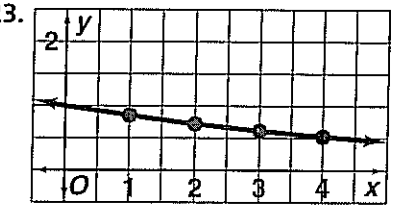
21.



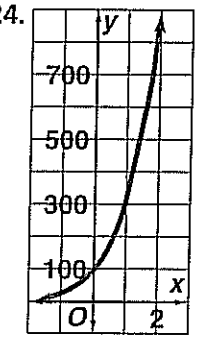
22.



23.



24.



25. $f(-2) = 5^{-2} = \frac{1}{5^2} = \frac{1}{25} = 0.04$, $5^{-1} = 0.2$, $5 \cdot 0.2 = 1$; 5, 25, 125; increase **26.** $2.5^{-2} = \frac{1}{2.5^2} = \frac{1}{6.25} = 0.16$, $2.5 \cdot 0.16 = 0.4$; 1, 2.5, 6.25, 15.625; increase **27.** $0.1^{-2} = \frac{1}{0.1^2} = 100$, $0.1 \cdot 100 = 10$; 1, 0.1, 0.01, 0.001; decrease **28.** $5 \cdot 4^{-2} = \frac{5}{4^2} = 0.3125$, $5 \cdot 4^{-1} = 1.25$, $4 \cdot 1.25 = 5$; 20, 80, 320; increase **29.** $0.5^{-2} = 2^2 = 4$, $0.5 \cdot 4 = 2$, 1, 0.5, 0.25, 0.125; decrease **30.** $\left(\frac{2}{3}\right)^{-2} = \left(\frac{3}{2}\right)^2 = \frac{9}{4}$, $\frac{2}{3} \cdot \frac{9}{4} = \frac{3}{2}$, $\frac{2}{3} \cdot \frac{3}{2} = 1$; $\frac{2}{3}$, $\frac{4}{9}$, $\frac{8}{27}$; decrease **31.** $4 \cdot 10^{-2} = 0.04$, $10 \cdot 0.04 = 0.4$; 4, 40, 400; 4000; increase **32.** $100 \cdot 0.3^{-2} = 100 \cdot \frac{1}{0.3^2} = 100 \cdot \frac{1}{0.09} = 1111.\overline{1}$, $100 \cdot 0.3^{-1} = 333.\overline{3}$; 100, 30, 9, 2.7; decrease

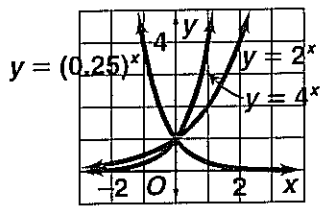
33a. Any function $y = a \cdot b^x$, where $a > 0$ and $b > 1$ or $a < 0$ and $0 < b < 1$. **33b.** Any function $y = a \cdot b^x$, where $a > 0$ and $0 < b < 1$ or $a < 0$ and $b > 1$.

34a.

Time	Number of 20-min Time Periods	Pattern	Number of Bacteria Cells
Initial	0	75	75
20 min	1	$75 \cdot 2$	$75 \cdot 2^1 = 150$
40 min	2	$75 \cdot 2 \cdot 2$	$75 \cdot 2^2 = 300$
60 min	3	$75 \cdot 2 \cdot 2 \cdot 2$	$75 \cdot 2^3 = 600$
80 min	4	$75 \cdot 2 \cdot 2 \cdot 2 \cdot 2$	$75 \cdot 2^4 = 1200$
100 min	5	$75 \cdot 2 \cdot 2 \cdot 2 \cdot 2 \cdot 2$	$75 \cdot 2^5 = 2400$
120 min	6	$75 \cdot 2 \cdot 2 \cdot 2 \cdot 2 \cdot 2 \cdot 2$	$75 \cdot 2^6 = 4800$
140 min	7	$75 \cdot 2 \cdot 2 \cdot 2 \cdot 2 \cdot 2 \cdot 2 \cdot 2$	$75 \cdot 2^7 = 9600$

34b. $y = 75 \cdot 2^x$, where x = number of 20-minute time periods; or $y = 75 \cdot 2^{\frac{t}{20}}$, where t = time in minutes.

35a.



35b. (0, 1) **35c.** No, there is no value of x where $y = 0$. **35d.** $y = a \cdot b^x$; if $b > 1$, the graph gets steeper as b increases. If $b < 1$, the graph gets steeper as b decreases.

36a. $y = 1 \cdot 1000^{\frac{150}{50}} = 1000^3 = 10^9$ plants

36b. $1000^{\frac{200}{50}} = 1000^4 = 10^{12}$ plants

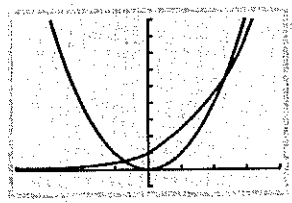
37a.

x	y
1	−2
2	4
3	−8
4	16
5	−32

37b. Every other value is negative. The absolute value of each term is double the previous term. **37c.** No; in $y = a \cdot b^x$, an exponential function requires $b > 0$. In this case $b = -2 < 0$, so $y = (-2)^x$ is not exponential.

38. $5^3 = 125$; $3^5 = 243$; $y = x^5$ is greater. **39.** $10 \cdot 2^7 = 1280$; $200 \cdot 7^2 = 9800$; $f(t) = 200 \cdot t^2$ is greater. **40.** $3^4 = 81$; $4^3 = 64$; $y = 3^x$ is greater. **41.** $2^{10} = 1024$; $100 \cdot 10^2 = 10{,}000$; $f(x) = 100x^2$ is greater. **42.** $f(x) = 500 \cdot 1^x = 500$ for $x = 1, 2, 3, 4$, and 5. Range = [500]. The definition of an exponential function excludes the case $b = 1$ because in that case $f(x)$ is a constant, and does not show exponential behavior.

43a.



43b. Between $x = 1$ and $x = 3$, the graph of $y = x^2$ rises faster than the graph of $y = 2^x$. The graphs intersect at $x = 2$. **43c.** The graph of $y = 6^x$ is steeper than $y = x^2$ and $y = 2^x$.

44.
$3^x = 9$
$3^x = 3^2$
$x = 2$

45.
$3^x = \frac{1}{27}$
$3^x = \frac{1}{3^3} = 3^{-3}$
$x = -3$

46.
$2^x = 64$
$2^x = 2^6$
$x = 6$

47.
$3 \cdot 2^x = 24$
$2^x = 8$
$2^x = 2^3$
$x = 3$

48.
$2 \cdot 3^x = 162$
$3^x = 81$
$3^x = 3^4$
$x = 4$

49.
$5 \cdot 2^x - 152 = 8$
$5 \cdot 2^x = 160$
$2^x = 32$
$2^x = 2^5$
$x = 5$

50a.
$y = a \cdot b^x$
$4 = a \cdot b^0$
$4 = a$

50b.
$36 = 4 \cdot b^2$
$9 = b^2$
$3^2 = b^2$
$3 = b$

50c. $y = 4 \cdot 3^x$ **50d.** $4 \cdot 3^{-2} = \frac{4}{9}$; $4 \cdot 3^4 = 324$

51. $y = -3^{-2} = -\frac{1}{3^2} = -\frac{1}{9}$; the answer is B.

52. **F.** $1.675 \cdot 1 + 1.325 = 3$ ✓; $1.675 \cdot 3 + 1.325 = 6.35$ no **G.** $2 \cdot 1.5^1 = 3$ ✓; $2 \cdot 1.5^3 = 6.75$ ✓ **H.** $1.5 \cdot 2^1 = 3$ ✓; $1.5 \cdot 2^3 = 12$ no **I.** $1.325 \cdot 1 + 1.675 = 3$ ✓; $1.325 \cdot 3 + 1.675 = 5.65$ no; the answer is G. **53.** When $x = 0$, $y = 2^0 = 1$; the answer is A. **54.** The answer is H. **55.** [2]

x	$y = 20 \cdot 0.5^x$	$y = 0.5 \cdot 4^x$
0	20	0.5
1	10	2
2	5	8

The graphs intersect between $x = 1$ and $x = 2$.
[1] no work shown

56. 5; 1250, 6250, 31,250 **57.** −3; 567, −1701, 5103

58. 2; −3.2, −6.4, −12.8 **59.** $-\frac{1}{3}, \frac{1}{3}, -\frac{1}{9}, \frac{1}{27}$ **60.** 0.1; 0.045, 0.0045, 0.00045 **61.** 0.25; 28, 7, 1.75

62. Point = (x_1, y_1); equation is $y - y_1 = m(x - x_1)$; $m = -5$; $y - 0 = 5(x - 0)$ or $y = 5x$ **63.** $y - 1 = 3(x - 0)$ or $y = 3x + 1$ **64.** $y - 0 = -2(x - 4)$ or $y = -2x + 8$

65. $y - (-3) = 0.4(x - 2)$ or $y = 0.4x - 3.8$

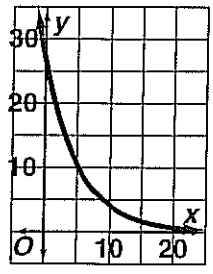
CHECKPOINT QUIZ 2 *page 435*

1. $\left(\frac{3^2}{3^{-1}}\right)^4 = (3^3)^4 = 3^{3\cdot4} = 3^{12}$ **2.** $\left(\frac{x^2}{y^3}\right)^{-5} = \left(\frac{y^3}{x^2}\right)^5 = \frac{y^{3\cdot5}}{x^{2\cdot5}} = \frac{y^{15}}{x^{10}}$ **3.** $\left(\frac{10m^{-3}}{25n^{-6}}\right)^2 = \left(\frac{2n^6}{5m^3}\right)^2 = \frac{(2n^6)^2}{(5m^3)^2} = \frac{4n^{12}}{25m^6}$ **4.** $\left(\frac{6^2t^{-3}}{6^2r^0t^2}\right)^2 = \left(\frac{1}{t^5}\right)^2 = \frac{1}{t^{10}}$ **5.** common ratio = 2; geometric **6.** common ratio = $\frac{1}{2}$; geometric **7.** common difference = 5; arithmetic **8a.** -100 **8b.** $-\frac{1}{5}$ or -0.2 **8c.** $A(n) = -100(-0.2)^{n-1}$ **8d.** $A(5) = -100(-0.2)^{5-1} = -100(-0.2)^4 = -100 \cdot 0.0016 = -0.16$; $A(7) = -100(-0.2)^{7-1} = -100(-0.2)^6 = -100 \cdot 0.000064 = -0.0064$ **9a.** The length of the nth swing is $A(n) = 40(0.85)^{n-1}$ **9b.** $A(5) = 40(0.85)^{5-1} = 40(0.85)^4 \approx 209$; 209 mm **10a.** 108 million $= 108 \times 10^6 = 1.08 \times 10^8$ **10b.** 249 million $= 2.49 \times 10^8$ **10c.** $\frac{\$2.49 \times 10^8}{1.08 \times 10^8 \text{ vehicles}} \approx$ \$2.31 per vehicle

TECHNOLOGY *page 436*

1a. $y = 26.87(0.83)^x$

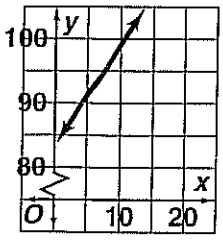
1b.



1c. $y(20) = 26.87(0.83)^{20} \approx 0.65$

2a. $y = 83.59\,(1.02)^x$

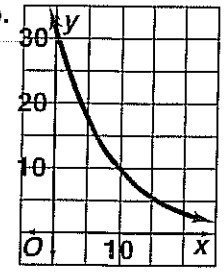
2b.



2c. $y(20) = 83.59(1.017)^{20} \approx 117.1$

3a. $y = 31.53(0.89)^x$

3b.



3c. $y(60) = 31.53(0.89)^{60} \approx 0.029$

8.8 Exponential Growth and Decay *pages 437–445*

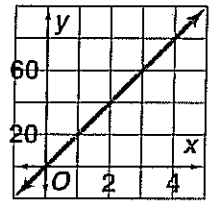
Check Skills You'll Need For complete solutions see *Daily Skills Check and Lesson Quiz Transparencies* or *Presentation Pro CD-ROM.*

1. \$100 **2.** \$64.80 **3.** \$225 **4.** \$352.80 **5.** \$324

Check Understanding **1a.** $y = 4512 \cdot 1.025^x$ **1b.** $y = 4512 \cdot 1.025^3 \approx 4859$ [students] **2a.** $y = 1500 \cdot 1.08^{18} \approx 5994.03$ [\$] **2b.** $B = 1500(1 + 0.08)^{18} = 5994.03$ [\$] **2c.** $(1 + r)$ is the same as $100\% + 100r\%$ written as a decimal. **3a.** interest rate per month $= \frac{6.5\%}{12} \approx 0.54167\%$; number of months $= 18 \cdot 12 = 216$; $y = 1500 \cdot 1.0054167^{216} = 4817.75$ [\$] **3b.** interest rate per month $= \frac{5}{12} = 0.41667\%$; after $x =$ 12 months $y = 200 \cdot 1.0041667^{12} = 210.23$ [\$]; after $x =$ 24 months $y = 200 \cdot 1.0041667^{24} = 220.99$ [\$]; after $x =$ 60 months $y = 200 \cdot 1.0041667^{60} = 256.67$ [\$] **4a.** $\frac{32}{8} =$ 4 [half-lives] **4b.** (50 mCi) $\cdot \frac{1}{2} = 25$ mCi; (50 mCi) $\cdot \frac{1}{2} \cdot \frac{1}{2} =$ 12.5 mCi **4c.** (30 mCi) $\cdot \frac{1}{2} = 15$ mCi; (30 mCi) $\cdot \frac{1}{2} \cdot \frac{1}{2} \cdot \frac{1}{2} = 3.75$ mCi **5a.** 604,000 **5b.** decay factor $= 100\% - 1.8\% = 1 - 0.018 = 0.982$ **5c.** $y = 604{,}000(0.982)^x$ **5d.** $y = 604{,}000(0.982)^{20} \approx 420{,}017$; about 420,017 people

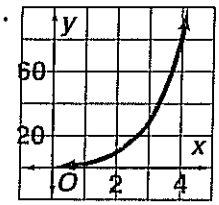
Exercises **1.** initial amount $= a = 20$; growth factor $= b = 2$ **2.** $a = 200$; $b = 1.0875$ **3.** 10,000; 1.01 **4.** 1; 1.5 **5a.** $a = 50{,}000$ **5b.** $b = 100\% + 3\% = 1 + 0.03 = 1.03$ **5c.** 1.03 **5d.** $y = 50{,}000 \cdot 1.03^x$ **5e.** $y = 50{,}000 \cdot 1.03^{25} \approx 104{,}689$ [people] **6.** $100\% + 4\% = 1 + 0.04 = 1.04$ **7.** $1 + 0.05 = 1.05$ **8.** $1 + 0.037 = 1.037$ **9.** $1 + 0.0875 = 1.0875$ **10.** $1 + 0.005 = 1.005$ **11.** $\frac{3\%}{4} = 0.75\%$; $\frac{3\%}{12} = 0.25\%$ **12.** $\frac{4\%}{4} = 1\%$; $\frac{4\%}{12} = \frac{1}{3}\%$ **13.** $\frac{4.5\%}{4} = 1.125\%$; $\frac{4.5\%}{12} = 0.375\%$ **14.** $\frac{7.6\%}{4} = 1.9\%$; $\frac{7.6\%}{12} = 0.6\overline{3}\%$ **15.** $\frac{6.25\%}{4} = 1.5625\%$; $\frac{6.25}{12} = 0.5208\overline{3}\%$ **16.** $4000 \cdot 1.06^5 = 5352.90$ [\$] **17.** $12{,}000 \cdot 1.048^7 = 16{,}661.35$ [\$] **18.** rate = 1% per quarter; period = 24 quarters; $500 \cdot 1.01^{24} = 634.87$ [\$] **19.** rate $= \frac{3.5\%}{4} = 0.875\%$ per quarter; period = 40 quarters; $20{,}000 \cdot 1.00875^{40} = 28{,}338.18$ [\$] **20a.** $\frac{16 \text{ days}}{4 \text{ days}} = 4$ [half-lives] **20b.** (40 mCi) $\left(\frac{1}{2}\right)^4 = 2.5$ mCi **21a.** $\frac{60 \text{ min}}{30 \text{ min}} = 3$ [half-lives] **21b.** (25 mCi) $\left(\frac{1}{2}\right)^3 = 3.125$ mCi **22.** 0.5 **23.** 0.1 **24.** $\frac{2}{3}$ **25.** 0.9 **26.** $2 > 1$; growth **27.** $0.68 < 1$; decay **28.** $2 > 1$; growth **29.** $0.2 < 1$; decay **30a.** \$22,000; $1 - 20\% = 0.8$ **30b.** $y = 22{,}000 \cdot (0.8)^x$ **30c.** $22{,}000 \cdot 0.8^6 \approx 5767.17$ **31.** $y = 130{,}000(1.01)^x$; $x = 9$; $y \approx 142{,}179$ **32.** $y = 3{,}000{,}000(0.985)^x$; $x = 10$; $y \approx 2{,}579{,}191$ **33.** $y = 2400(1.07)^x$; $x = 10$; $y = 4721.16$ [\$] **34.** $\frac{7\%}{12} = 0.58\overline{3}\%$; $y = 2400(1.00583)^x$; $x = 120$; $y = 4823.19$ [\$] **35a.** $y = 584(1.065)^x$; $x = 20$; $y \approx 2058$ [\$] **35b.** Check students' work. **36.** Linear; it is a straight line. **37.** Neither; it is not a single straight line. **38.** Curve resembles an exponential function; $y(x)$ increases with an ever-increasing slope. **39.** Neither; y decreases and then increases.

40.

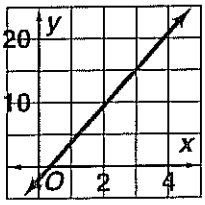


linear function

41.



exponential function

42. 

linear function **43.** \$600; the account with \$600 starts out larger and stays larger for many years; the \$500 account overtakes the \$600 account only after 17 years. **44.** $\frac{48 \text{ hours}}{8 \text{ hours}}$ = 6 half-lives **45.** $\frac{300 \text{ years}}{75 \text{ years}} = 4$ half-lives

46a. about 4 h **46b.** $\frac{1}{2} \cdot \frac{1}{2} = \frac{1}{4}$ **46c.** by estimate, $\frac{15 \text{ mg}}{4}$ = 3.75 mg; by function, $(15 \text{ mg})0.84^8 \approx 3.72$ mg **47a.** $y = 6{,}284{,}000(1.01)^x$ **47b.** $y = 6{,}284{,}000(1.01)^{20} \approx 7{,}667{,}674$ **48.** $1 - 6\% = 94\%$ **49.** $1 - 12\% = 88\%$ **50.** $1 - 3.5\% = 96.5\%$ **51.** $1 - 53.9\% = 46.1\%$ **52a.** Initial level = 500 mCi; level drops to half of this (250 mCi) after 2 years. **52b.** $\frac{200 \text{ mCi}}{800 \text{ mCi}} = \frac{1}{4} = \frac{1}{2} \cdot \frac{1}{2}$; two half-lives = 4 years **53a.** $250 - 30 = 220$ [All amounts are in dollars.] **53b.** $220 \cdot 0.018 = 3.96$ **53c.** $220 + 3.96 = 223.96$ **53d.** $223.96 - 30 = 193.96$ **53e.** Repeating this calculation, find account paid off after 9 months. **53f.** Interest payments add up to \$18.07.

54. approximate rule: $x = \frac{72}{r}$; exact: $y = (1 + r)^x$

Rate r (%)	Years to double, x (rule of 72)	Exact increase, y
1	72	2.047
2	36	2.040
3	24	2.033
4	18	2.026
6	12	2.012
8	9	1.999
9	8	1.992
12	6	1.974
18	4	1.939
24	3	1.907
36	2	1.850

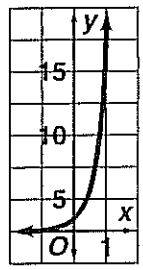
The rule of 72 becomes inaccurate only for extremely high interest rates.

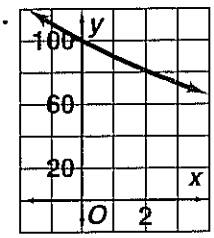
55.

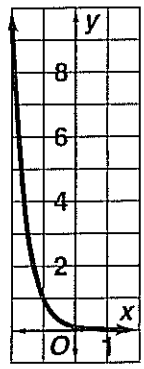
End of Year	x	$40{,}000(1.07)^x$	$60{,}000(0.96)^x$
2000	1	42,800	57,600
2001	2	45,796	55,296
2002	3	49,002	53,084
2003	4	52,432	50,961

Chessville's population exceeds Checkersville's during 2003.

56. Only C has a base < 1; the answer is C.
57. $1000 \cdot 1.03^{10} = 1343.92$; the answer is H.
58. $24 \cdot 1.045^{374} = 339{,}000{,}000$; the answer is A.
59. [2] $1.0125^{20} = 1.282$; $1.055^5 = 1.307$; account paying 5.5% will be larger. [1] minor computational error

60. 

61. 

62. 

63. $(1.4 \times 10^4)(5.2 \times 10^7) = (1.4 \cdot 5.2)(10^{4+7}) \approx 7.28 \times 10^{11}$ [gal]

READING MATH *page 445*

a. about 9 or 10 words **b.** $40 \cdot 0.75^5 \approx 9.49$; 9 or 10 words

TEST-TAKING STRATEGIES *page 446*

1. Test terms $x - 2$, x, and $x + 3$. **A.** 2, 4, 7, no **B.** 4, 6, 9 ✓ **C.** 6, 8, 11, no **D.** 8, 10, 13, no. The answer is B.

2. F. $\frac{1}{-2} + \frac{1}{(-2)^2} = -\frac{1}{4}$, no **G.** $\frac{1}{-1} + \frac{1}{(-1)^2} = 0$ ✓ **H.** $1 + 1 = 2$, no **I.** $\frac{3}{4}$; the answer is G. **3. A.** $(0.00011)^2 = 1.21 \times 10^{-8}$, no **B.** $(0.0011)^2 = 1.21 \times 10^{-6}$, no **C.** $(0.011)^2 = 1.21 \times 10^{-4}$ ✓ **D.** $(0.11)^2 = 1.21 \times 10^{-2}$, no; the answer is C. **4.** Test terms x, $3x + 1$, and $6x - 1$. **F.** $-3, -8, -19$, no **G.** $-1, -2, -7$, no **H.** 1, 4, 17, no **I.** 3, 10, 17 ✓; the answer is I.

CHAPTER REVIEW *pages 447–449*

1. exponential growth **2.** growth factor **3.** scientific notation **4.** exponential decay **5.** decay factor **6.** compound interest **7.** common ratio **8.** interest period, at the end of which the interest is recompounded **9.** geometrical sequence **10.** exponential function **11.** $b^{-4}c^0d^6 = \frac{d^6}{b^4}$ **12.** $\frac{x^{-2}}{y^{-8}} = \frac{y^8}{x^2}$ **13.** $7k^{-8}h^3 = \frac{7h^3}{k^8}$ **14.** $\frac{1}{p^2q^{-4}4^0} = \frac{q^4}{p^2}$ **15.** $\left(\frac{2}{5}\right)^{-4} = \left(\frac{5}{2}\right)^4 = \frac{5^4}{2^4} = \frac{635}{16}$ **16.** $(-2)^{-3} = \frac{1}{(-2)^3} = \frac{1}{-8} = -\frac{1}{8}$ **17.** $-2^{-3} = -(2)^{-3} = -\frac{1}{2^3} = -\frac{1}{8}$ **18.** $7^{-2}y^{-4} = \frac{1}{49y^4}$ **19.** $\frac{9w^{-4}}{x^{-2}y^7} = \frac{9x^2}{w^4y^7}$ **20.** $2^2(-3)^2 = 4 \cdot 9 = 36$ **21.** $(-2)^2(-3)^{-2} = \frac{4}{(-3)^2} = \frac{4}{9}$ **22.** $2^{-3}(-3)^2 = \frac{9}{2^3} = \frac{9}{8}$ **23.** $2^0(-3)^0 = 1$ **24.** $-2^2(-3)^3 = -4 \cdot -27 = 108$ **25. A.** $4^{-3} = \frac{1}{64}$ **B.** $(-3)^0 = 1$ **C.** $\frac{1}{(-3)^{-4}} = (-3)^4 = 81$ **D.** $\frac{4^0}{(-3)^0} = 1$

E. $\frac{0}{4^{-(-3)}} = 0$; the answer is C. **26.** No; $(-3b)^4 = 81b^4$, which (if $b \neq 0$) does not equal $-12b^4$. **27.** No; $950 > 10$. **28.** No; $72.35 > 10$. **29.** yes **30.** No; $0.84 < 1$. **31.** $2{,}793{,}000 = 2.793 \times 10^6$ [mi] **32.** $189{,}000{,}000 = 1.89 \times 10^8$ [cars and trucks] **33.** $2d^2d^3 = 2d^{2+3} = 2d^5$ **34.** $(q^3r)^4 = q^{3\cdot4}r^4 = q^{12}r^4$ **35.** $(5c^{-4})(-4m^2c^8) = -20m^2c^{8-4} = -20m^2c^4$ **36.** $(1.34^2)^5(1.34)^{-8} = 1.34^{2\cdot5} \cdot 1.34^{-8} = 1.34^{10} \cdot 1.34^{-8} = 1.34^2$

37. $(12x^2y^{-2})^5(4xy^{-3})^{-8} = \left(\frac{12x^2}{y^2}\right)^5\left(\frac{4x}{y^3}\right)^{-8} = \frac{12^5x^{10}}{y^{10}} \cdot \left(\frac{y^3}{4x}\right)^8 = \frac{3^54^5x^{10}}{y^{10}} \cdot \frac{y^{24}}{4^8x^8} = \frac{3^5x^2y^{14}}{4^3} = \frac{243x^2y^{14}}{64}$

38. $(-2r^{-4})^2(-3r^2z^8)^{-1} = \left(\frac{-2}{r^4}\right)^2\left(\frac{1}{-3r^2z^8}\right) = \frac{4}{r^8} \cdot \frac{1}{-3r^2z^8} - \frac{4}{3r^{10}z^8}$

39. $\left(6.5 \times 10^2 \frac{\text{pores}}{\text{in.}^2}\right) \cdot (0.12 \times 10^2 \text{ in.}^2) = (6.5 \cdot 0.12) \times 10^{2+2}$ pores $= 0.78 \times 10^4$ pores $= 7.8 \times 10^3$ pores **40.** Answers may vary. Sample:

$(2a^{-2})^{-2}(-3a)^2 = \left(\frac{1}{2a^{-2}}\right)^2 \cdot 9a^2 = \left(\frac{a^2}{2}\right)^2 \cdot 9a^2 = \frac{9a^6}{4}$

41. $\frac{w^2}{w^5} = \frac{1}{w^{5-2}} = \frac{1}{w^3}$ **42.** $(8^3) \cdot 8^{-5} = 8^{3+(-5)} = 8^{-2} = \frac{1}{64}$ **43.** $\left(\frac{21x^3}{3x}\right) = 7x^{3-1} = 7x^2$ **44.** $\left(\frac{n^5}{v^3}\right)^7 = \frac{n^{5\cdot7}}{v^{3\cdot7}} = \frac{n^{35}}{v^{21}}$

45. $\frac{e^{-6}c^3}{e^5} = \frac{c^3}{e^{5+6}} = \frac{c^3}{e^{11}}$ **46.** $\frac{4.2 \times 10^8}{2.1 \times 10^{11}} = \frac{4.2}{2.1} \cdot 10^{8-11} = 2 \times 10^{-3}$ **47.** $\frac{3.1 \times 10^4}{12.4 \times 10^2} = \frac{1}{4} \cdot 10^{4-2} = \frac{1}{4} \times 10^2 = 2.5 \times 10^1$ **48.** $\frac{4.5 \times 10^3}{9 \times 10^7} = \frac{1}{2} \cdot 10^{-4} = 5 \times 10^{-5}$

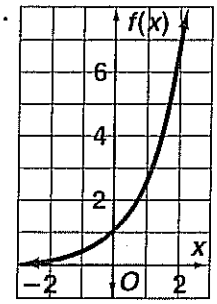
49. $\frac{5.1 \times 10^5}{1.7 \times 10^2} = 3 \times 10^{5-2} = 3 \times 10^3$

50. $\left(\frac{5a^8}{10a^6}\right)^{-3} = \left(\frac{a^{8-6}}{2}\right)^{-3}$ Simplify; div. prop. of exp.
$= \left(\frac{a^2}{2}\right)^{-3}$ Simplify.
$= \left(\frac{2}{a^2}\right)^3$ Raise quotient to neg. power.
$= \frac{2^3}{(a^2)^3}$ Raise quotient to power.
$= \frac{8}{a^6}$ Simplify; raise power to a power.

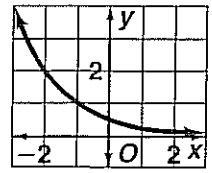
51. $\frac{75}{750} = 0.1$ **52.** $\frac{0.36}{0.12} = 3$ **53.** $\frac{-\frac{5}{2}}{5} = -\frac{1}{2}$ **54.** geometric; $\frac{25}{4}, \frac{25}{16}, \frac{25}{64}$ **55.** Neither; differences are 1, 2, 3, 4, and 5; next terms are -30, -25, and -19. **56.** arithmetic; 42, 49, 56 **57.** $f(1) = 3 \cdot 2^1 = 6$; $3 \cdot 2^2 = 3 \cdot 4 = 12$; $3 \cdot 2^3 = 3 \cdot 8 = 24$; $3 \cdot 2^4 = 3 \cdot 16 = 48$ **58.** $y(1) = 10 \cdot (0.75)^1 = 7.5$; $10 \cdot (0.75)^2 = 5.625$; $10 \cdot (0.75)^3 = 4.21875$ **59a.** Number of tripling periods $= \frac{120}{30} = 4$; $30 \cdot 3^4 = 2430$ [bacteria] **59b.** $\frac{20{,}000}{30} \approx 667 = 3^x$; $3^5 = 243$; $3^6 = 729$; after about 6 tripling periods or 180 min

60. $y = a \cdot b^x$; $a = 100, b = 1.025$ **61.** $a = 32, b = 0.75$ **62.** $a = 0.4, b = 2$ **63.** growth factor $= 3$ (>1) **64.** growth factor $= 1.5$ (>1) **65.** decay factor $= 0.32$ (<1) **66.** decay factor $= \frac{1}{4}$ (<1)

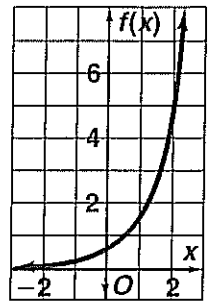
67.



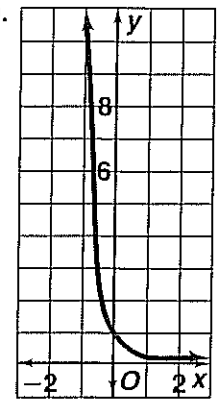
68.



69.



70.



71. $25 \cdot 0.80^5 \approx 8.2$ [mg]

CHAPTER TEST *page 450*

1. $\frac{r^3t^{-7}}{t^5} = \frac{r^3}{t^{5+7}} = \frac{r^3}{t^{12}}$ **2.** $\left(\frac{a^3}{m}\right)^{-4} = \left(\frac{m}{a^3}\right)^4 = \frac{m^4}{a^{3\cdot4}} = \frac{m^4}{a^{12}}$ **3.** $\frac{t^{-8}m^2}{m^{-3}} = \frac{m^{2+3}}{t^8} = \frac{m^5}{t^8}$ **4.** $c^3v^9c^{-1}c^0 = c^{3-1}v^9 = c^2v^9$

5. $h^2k^{-5}d^3k^2 = h^2d^3k^{-5+2} = h^2d^3k^{-3} = \frac{h^2d^3}{k^3}$

6. $9y^4j^2y^{-9} = 9j^2y^{-5} = \frac{9j^2}{y^5}$ **7.** $(w^2k^0p^{-5})^{-7} = \left(\frac{w^2}{p^5}\right)^{-7} = \left(\frac{p^5}{w^2}\right)^7 = \frac{p^{35}}{w^{14}}$ **8.** $2y^{-9}h^2(2y^0h^{-4})^{-6} = 2y^{-9}h^2\left(\frac{2}{h^4}\right)^{-6} = 2y^{-9}h^2\left(\frac{h^4}{2}\right)^6 = 2y^{-9}h^2\left(\frac{h^{24}}{64}\right) = \frac{h^{26}}{32y^9}$

9. $(1.2)^5(1.2)^{-2} = (1.2)^{5-2} = (1.2)^3 = 1.728$

10. $(-3q^{-1})^3q^2 = \left(\frac{-3}{q}\right)^3 q^2 = \left(\frac{-27}{q^3}\right) q^2 = \frac{-27}{q}$

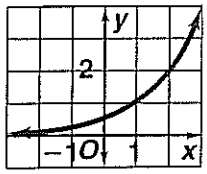
11. A. $(-3)^2(-3)^0 = 9$ **B.** $(-3)^{-3} = \left(\frac{1}{-3}\right)^3 = -\frac{1}{27}$ **C.** $(-3)^8(-3)^{-5} = (-3)^3 = -27$ **D.** $-(-3)^{-3}(-3)^{-4} = -(-3)^{-7} = -\left(\frac{1}{-3}\right)^7 = \frac{1}{2187}$; the answer is C.

12. $44{,}909{,}000 = 4.4909 \times 10^7$ [votes] **13.** $450{,}000 = 4.5 \times 10^5$ **14.** No; $76 > 10$. **15.** yes **16.** No; there are two powers of 10. **17.** No; $32.5 > 10$.

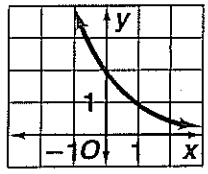
18a. $\left(1.863 \times 10^5 \frac{\text{mi}}{s}\right)\left(\frac{3600 \text{ s}}{1 \text{ h}}\right) = 6.7068 \times 10^8 \frac{\text{mi}}{\text{h}}$; about 6.7068×10^8 mi **18b.** time $= \frac{\text{distance}}{\text{rate}} = \frac{1.03 \times 10^9 \text{ mi}}{6.7068 \times 10^8 \frac{\text{mi}}{\text{h}}} \approx 1.5$ h **19a.** $\frac{-8}{16} = -\frac{1}{2}$ **19b.** $-2, 1, -\frac{1}{2}$ **19c.** $A(n) = -32\left(-\frac{1}{2}\right)^{n-1}$ **19d.** $A(9) = -32\left(-\frac{1}{2}\right)^{9-1} = -32\left(-\frac{1}{2}\right)^8 = -2^5\left(\frac{1}{2^8}\right) = -\frac{1}{2^3} = -\frac{1}{8}$ **20a.** Height of $(n-1)$th bounce $= A(n) = 12 \cdot \left(\frac{3}{5}\right)^{n-1}$ **20b.** after third bounce $(n = 4)$, $A(4) = 12 \cdot \left(\frac{3}{5}\right)^{4-1} = 12 \cdot (0.6)^3 =$

2.592 [ft] **21.** $A(5) = -3(-2)^{5+1} = -3(-2)^6 = -3 \cdot 64 = -192$ **22.** $y(1) = 3 \cdot 5^1 = 15; 3 \cdot 5^2 = 75; 3 \cdot 5^3 = 375$ **23.** $\frac{1}{2} \cdot 4^1 = 2; \frac{1}{2} \cdot 4^2 = 8; \frac{1}{2} \cdot 4^3 = 32$ **24.** $4(0.95)^1 = 3.8$; $4(0.95)^2 = 3.61$; $4(0.95)^3 = 3.4295$ **25.** $g(1) = 5(0.75)^1 = 3.75$; $5(0.75)^2 = 2.8125$; $5(0.75)^3 = 2.109375$

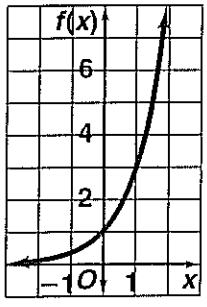
26.



27.



28.



29. Answers may vary. Sample: A computer loses 20% of its value each year. How much will a \$3000 computer be worth in 3 years? \$1792 **30.** growth for $b > 1$; decay for $0 < b < 1$ **31.** $1000 \cdot 1.01^8 = 1082.86$ [\$]; $1000 \cdot 1.01^{20} = 1220.19$ [\$] **32a.** growth; growth factor $1.07 > 1$ **32b.** $1.3 \cdot (1.07)^{25} \approx 7.1$ [kWh] **32c.** $1.3 \cdot (1.07)^{-10} \approx 0.66$ [kWh]

32d.

Year	x	$1.3 \cdot (1.07)^x$ (kWh)
2002	17	4.1
2003	18	4.4
2004	19	4.7
2005	20	5.0
2006	21	5.4

33a. 0.85; the car's value depreciates 15% annually. **33b.** $20{,}000(0.85)^1 = 17{,}000$ [\$] **33c.** $20{,}000(0.85)^4 = 10{,}440$ [\$] **34a.** 8% **34b.** \$10,000; $10 \cdot 1.08^3 = 12.59712$; \$12,597.12

34c.

Year	x	$\$10{,}000 \cdot 1.08^x$
2003	6	\$15,869
2004	7	\$17,138
2005	8	\$18,509
2006	9	\$19,990
2007	10	\$21,589

STANDARDIZED TEST PREP *page 451*

1. The answer is C.

2. mean $= \frac{88 + 78 + 81 + 83 + 90 + x}{6} = 85$

$$420 + x = 6 \cdot 85 = 510$$
$$x = 510 - 420$$
$$x = 90$$

The answer is F.

3.
$$5 - 6x < -x + 2$$
$$5 - 5x < 2$$
$$-5x < -3$$
$$x > \tfrac{3}{5} = 0.6$$

The answer is A.

4. Commision on \$500 is \$30, so sales were greater than \$500.

$$30 + 0.1(x - 500) = 130$$
$$0.1(x - 500) = 100$$
$$x - 500 = 1000$$
$$x = 1500$$

The answer is I.

5.
$$\tfrac{1}{3}x - y = 4$$
$$x - 3y = 12$$
$$\underline{x + 3y = 0}$$
$$2x = 12$$
$$x = 6$$
$$6 + 3y = 0$$
$$3y = -6$$
$$y = -2$$

The answer is C.

6. $P(\text{head, 3 or 6}) = \frac{1}{2} \cdot \frac{2}{6} = \frac{1}{6}$; answer is G.

7. The answer is D. **8.** $\frac{75h}{12.5h} = 6$; the answer is F.

9. $-3a^8cb^{-3}b^{12} \cdot 9c^5 = -27a^8b^{12-3}c^{1+5} = -27a^8b^9c^6$; the answer is B.

10. (1)
$$y > x + 4$$
$$y > -x + 4$$

The solutions of the system lie above both lines. Since the lines intersect at (0, 4), every solution satisfies $y > 4$. The answer is I.

11. The answer is A.

12.
$$1 + y = 9$$
$$x + 3 = 6$$
$$y = 8$$
$$x = 3$$

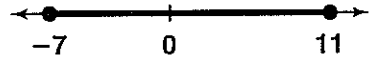
The answer is B.

13. $0.21 \cdot 9 = 1.89$ **14.** $P = \frac{3}{6} = \frac{1}{2}$ **15.** [2] x: 2000; y: 1990; $x = (1 + 0.132)y$; $y = \frac{x}{1.132} = \frac{281{,}421{,}906}{1.132} = 248{,}605{,}924$ [people]; [1] no work shown

16. $x - 2 \le 9$ and $x - 2 \ge -9$

$$x \le 11 \text{ and } x \ge -7$$
$$-7 \le x \le 11$$

[2] $|x - 2| \le 9$



[1] no work shown

17. [4] Yes; rectangles have opposite sides that are parallel and adjacent sides that are perpendicular, so 2 slopes must be equal and the remaining 2 slopes must be their negative reciprocals. [3] yes, with an explanation that neglects to mention either parallel or perpendicular [2] yes, with a vague explanation [1] yes, with no explanation