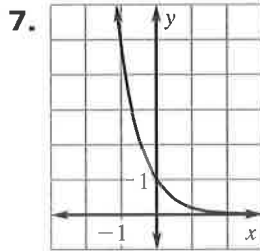


Answers for 8.6

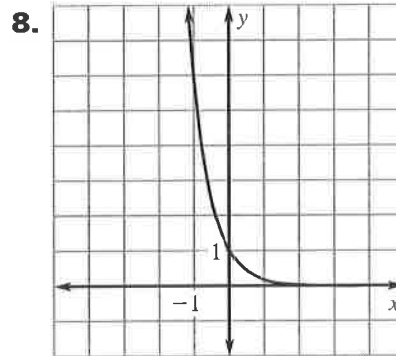
For use with pages 535–541

8.6 Skill Practice

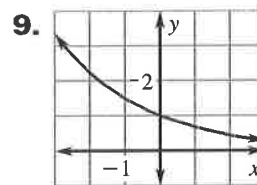
- $1 - r$
- Sample answer:* If the graph increases from left to right, then it represents growth; if it decreases from left to right, then it represents decay.
- exponential function; $y = 8 \cdot 4^x$
- exponential function;
 $y = 10(0.2)^x$
- exponential function; $y = 2\left(\frac{1}{3}\right)^x$
- not an exponential function



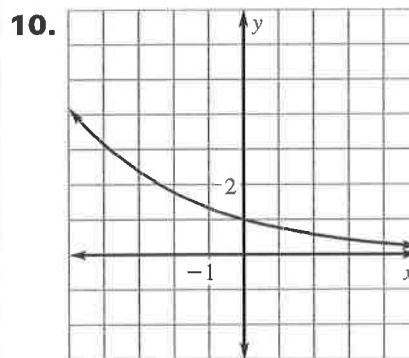
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domain: all real numbers
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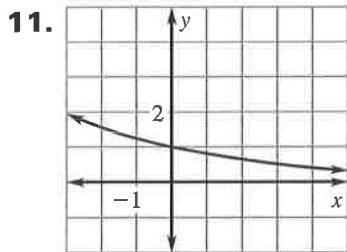


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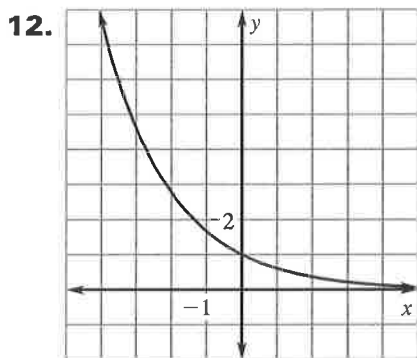


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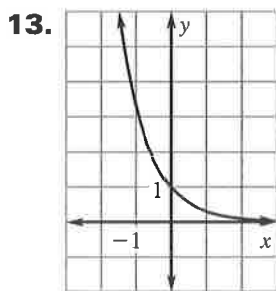
Answers for 8.6 *continued*
 For use with pages 535–541



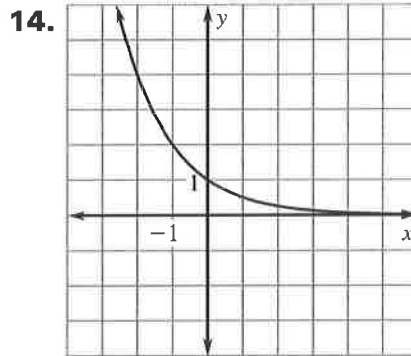
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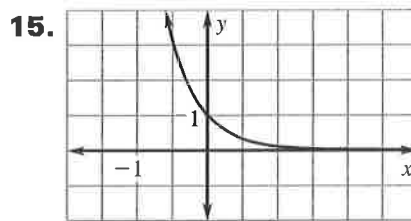
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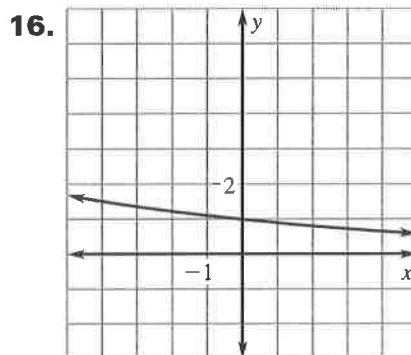
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domain: all real numbers
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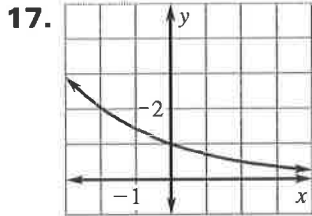


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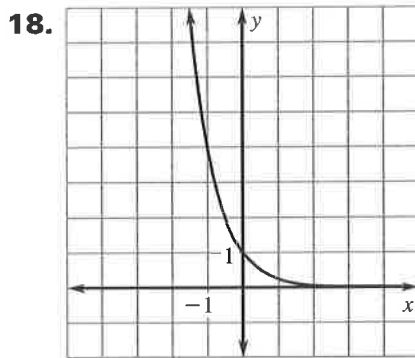


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Answers for 8.6 *continued*
 For use with pages 535–541

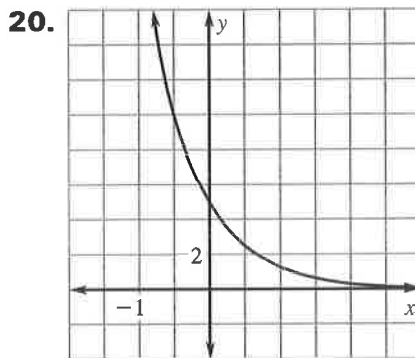


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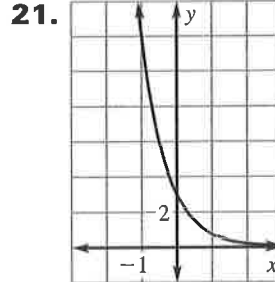


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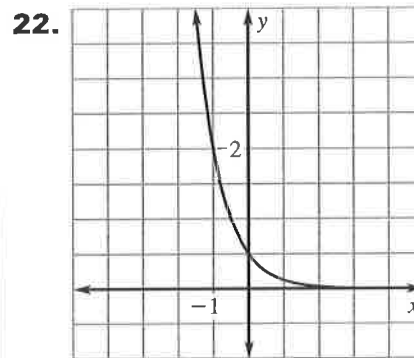
19. D



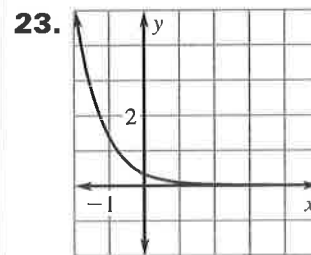
The graph is a vertical stretch.



The graph is a vertical stretch.

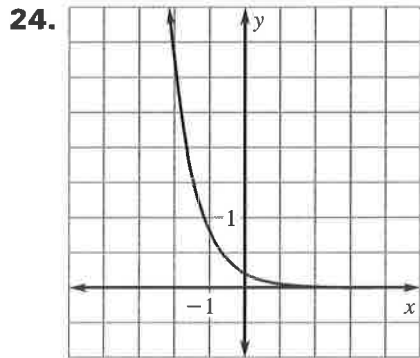


The graph is a vertical shrink.

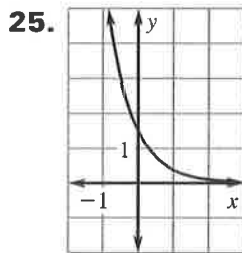


The graph is a vertical shrink.

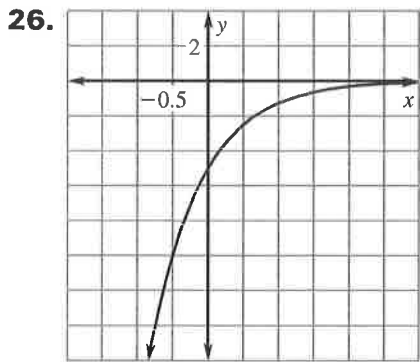
Answers for 8.6 *continued*
 For use with pages 535–541



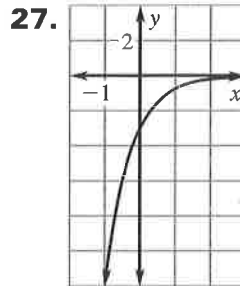
The graph is a vertical shrink.



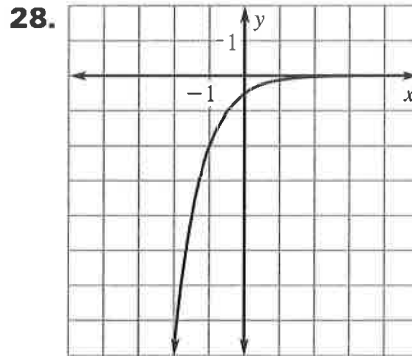
The graph is a vertical stretch.



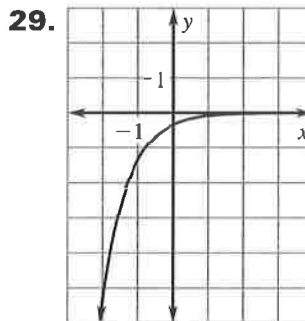
The graph is a vertical stretch with a reflection in the x -axis.



The graph is a vertical stretch with a reflection in the x -axis.

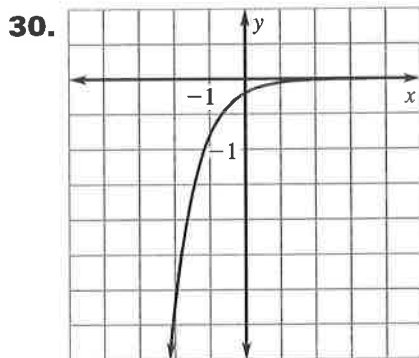


The graph is a vertical shrink with a reflection in the x -axis.

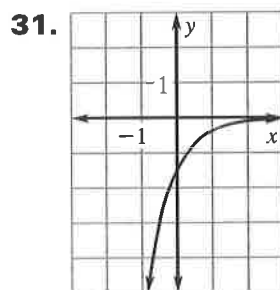


The graph is a vertical shrink with a reflection in the x -axis.

Answers for 8.6 *continued*
For use with pages 535–541



The graph is a vertical shrink with a reflection in the x -axis.



The graph is a vertical stretch with a reflection in the x -axis.

32. A 33. C 34. B

35. initial amount: 90,000 people,
decay factor: 0.975,
decay rate: 2.5%;
Let P represent the population and
 t represent the number of years.
 $P = 90,000(0.975)^t$

36. D

37. The decay rate, r , is 0.14. So the decay factor $(1 - r)$ should be 0.86, not 0.14; $y = 25,000(0.86)^t$.

38. exponential decay; $y = 6 \cdot 0.8^x$

39. exponential decay; $y = 8 \cdot 0.6^x$

40. exponential growth; $y = 8 \cdot 1.6^x$

41. a. The graph is a vertical shrink.

b. The graph is a vertical stretch with a reflection in the x -axis.

c. The graph is a vertical shift up 1 unit.

42. $y = \left(\frac{1}{2}\right)^x$ 43. $y = 100 \cdot \left(\frac{1}{5}\right)^x$

44. $y = 3 \cdot \left(\frac{1}{2}\right)^x$

45. *Sample answer:* Since the quantity loses the same percent each time period, the amount y remaining after x time periods can be modeled using the exponential function $y = a(1 - r)^x$. After 1 time period, when x is 1, $y = a(1 - r)^1$, or $a(1 - r)$.

46. *Sample answer:* The graphs are the same. By the product of powers property,
 $4^x - 2 = 4x \cdot 4^{-2}$, or $\frac{1}{16} \cdot 4x$.

8.6 Problem Solving

47. Let V represent the value of the cell phone and t represent the number of years since purchase,
 $V = 125(0.8)^t$; \$64.

Answers for 8.6 *continued*
For use with pages 535–541

48. a. initial amount: 141,200; decay factor: 0.89; decay rate: 11%

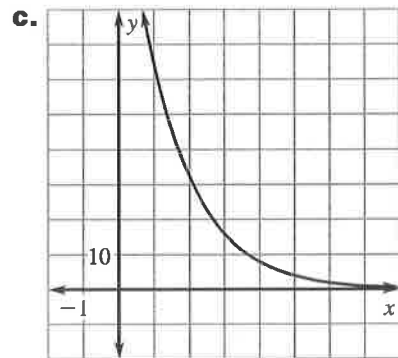
b. Let B represent the number of bats and t represent the number of years since 1983,
 $B = 141,200(0.89)^t$;
13,729 bats.

49. No. *Sample answer:* The boat's value is worth about \$3217.

50. a. $f(x) = 128(0.5)^x$

b.

Rounds completed	Teams remaining
0	128
1	64
2	32
3	16
4	8
5	4
6	2
7	1



round 5

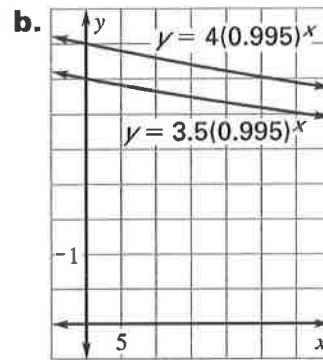
51. a. decay factor: 0.9439,
decay rate: 5.61%

b. about 1.431 in.

c. about 0.716 in.

52. \$1096.12

53. a. $y = 4(0.995)^x$, $y = 3.5(0.995)^x$



c. about 52 yr

8.6 Mixed Review

54. $-15x$

55. $5x$

56. $14 + 3x$

57. $14x + 2$

58. $18x - 20$

59. $9x + 54$

60. 5

61. $21x - 7$

62. $-x^2 - x + 1$

63. -6

64. 3

65. 4

66. -11

Answers for 8.6 *continued*
For use with pages 535–541

8.4–8.6 Mixed Review of Problem Solving

1. a. Sun: 9.66×10^7 km,
Earth: 6.37×10^3 km
b. Sun: about 1.17×10^{17} km,
Earth: about 5.10×10^8 km
c. about 2.23×10^8 ; *Sample answer:* the Sun's surface area is 223,000,000 times larger than the Earth's.

2. a. $y = 25,000(0.95)^x$
b. 5%; the decay rate for the truck is 0.05, or 5%.

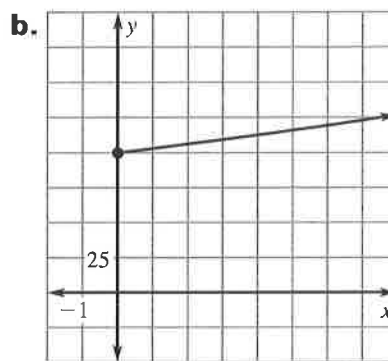
3. 0.18;

	.	1	8
	<input checked="" type="radio"/>	<input checked="" type="radio"/>	
	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
0	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
1	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
2	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
3	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
4	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
5	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
6	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
7	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
8	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
9	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

4. Let V represent the value of the house and t represent the number of quarters since 2001; $V = 200,000(1.04)^t$. *Sample answer:* A house with a value of \$200,000 at the end of 2002

would have a value of about \$275,000 at the end of 2004.

5. a. Let y represent the amount of money in the account and x represent the number of years since the \$100 was deposited.
 $y = 100(1.03)^x$



- c. No. *Sample answer:* There will only be \$109.27 in the account in 3 years.

6. a. exponential growth

b. $y = 15,000(1.3)^x$

c. \$42,841.50

7. a. Let M represent the amount of medication in patient's bloodstream (in milligrams) and let t represent the number of 8 hour periods since the medication was taken.

$$M = 500\left(\frac{1}{2}\right)^t$$

- b. 62.5 mg

REVIEW KEY VOCABULARY

- order of magnitude, p. 491
- exponential function, p. 520
- exponential decay, p. 533
- zero exponent, p. 503
- exponential growth, p. 522
- decay factor, decay rate, p. 534
- negative exponent, p. 503
- growth factor, growth rate, p. 522
- scientific notation, p. 512
- compound interest, p. 523

VOCABULARY EXERCISES

- Copy and complete: The function $y = 1200(0.3)^t$ is an exponential ? function, and the base 0.3 is called the ?. decay, decay factor
- WRITING** Explain how you can tell whether a table represents a linear function or an exponential function. See margin.

Tell whether the function represents exponential growth or exponential decay. Explain. 3–5. See margin.

- $y = 3(0.85)^x$
- $y = \frac{1}{2}(1.01)^x$
- $y = 2(2.1)^x$

REVIEW EXAMPLES AND EXERCISES

Use the review examples and exercises below to check your understanding of the concepts you have learned in each lesson of Chapter 8.

8.1 Apply Exponent Properties Involving Products

pp. 489–494

EXAMPLE

Simplify $(3y^3)^4 \cdot y^5$.

$$\begin{aligned} (3y^3)^4 \cdot y^5 &= 3^4 \cdot (y^3)^4 \cdot y^5 && \text{Power of a product property} \\ &= 81 \cdot y^{12} \cdot y^5 && \text{Power of a power property} \\ &= 81y^{17} && \text{Product of powers property} \end{aligned}$$

EXERCISES

Simplify the expression.

- $4^4 \cdot 4^3 \cdot 4^7$
- $(-3)^7(-3) (-3)^8$
- $z^3 \cdot z^5 \cdot z^5 \cdot z^{13}$
- $(y^4)^5 \cdot y^{20}$
- $[(-7)^4]^4 (-7)^{16}$
- $[(b+2)^8]^3 (b+2)^{24}$
- $(6^4 \cdot 31)^5 \cdot 6^{20} \cdot 31^5$
- $-(8xy)^2 - 64x^2y^2$
- $(2x^2)^4 \cdot x^5 \cdot 16x^{13}$

- EARTH SCIENCE** The order of magnitude of the mass of Earth's atmosphere is 10^{18} kilograms. The order of magnitude of the mass of Earth's oceans is 10^3 times greater. What is the order of magnitude of the mass of Earth's oceans? 10^{21}

EXAMPLES
1, 2, 3, 4,
and 5
on pp. 489–491
for Exs. 6–15

Extra Example 8.1

Simplify $[(d+4)^3]^2 \cdot (d+4)^6$

2. **Sample answer:** If the difference of each pair of successive terms is constant, the table represents a linear function. If the ratio of each pair of successive terms is constant, the table represents an exponential function.

3. Exponential decay; $b = 0.85$ which is between 0 and 1, therefore it is exponential decay.

4. Exponential growth; $b = 1.01$ which is greater than 1, therefore it is exponential growth.

5. Exponential growth; $b = 2.1$ which is greater than 1, therefore it is exponential growth.

8

CHAPTER REVIEW

Extra Example 8.2

Simplify $\left(\frac{2y^3}{z}\right)^5 \cdot \frac{1}{y^2} \cdot \frac{32y^{13}}{z^5}$

Extra Example 8.3

Evaluate $(4x^{-4}y^0)^{-2} \cdot \frac{x^9}{16}$

8.2 Apply Exponent Properties Involving Quotients

pp. 495–501

EXAMPLE

Simplify $\left(\frac{x^3}{y}\right)^4 \cdot \frac{2}{x^5}$.

$$\left(\frac{x^3}{y}\right)^4 \cdot \frac{2}{x^5} = \frac{(x^3)^4}{y^4} \cdot \frac{2}{x^5}$$

Power of a quotient property

$$= \frac{x^{12}}{y^4} \cdot \frac{2}{x^5}$$

Power of a power property

$$= \frac{2x^{12}}{y^4x^5}$$

Multiply fractions.

$$= \frac{2x^7}{y^4}$$

Quotient of powers property

EXAMPLES

1, 2, and 3
on pp. 495–496
for Exs. 16–24

EXERCISES

Simplify the expression.

16. $\frac{(-3)^7}{(-3)^3} (-3)^4$

17. $\frac{5^2 \cdot 5^4}{5^3} 5^3$

18. $\left(\frac{m}{n}\right)^3 \frac{m^3}{n^3}$

19. $\frac{17^{12}}{17^8} 17^4$

20. $\left(-\frac{1}{x}\right)^4 \frac{1}{x^8}$

21. $\left(\frac{7x^5}{y^2}\right)^2 \frac{49x^{10}}{y^4}$

22. $\frac{1}{p^2} \cdot p^6 \cdot p^4$

23. $\frac{6}{7r^{10}} \cdot \left(\frac{s^5}{s}\right)^5 \frac{6r^{15}}{7s^5}$

24. **PER CAPITA INCOME** The order of magnitude of the population of Montana in 2003 was 10^6 people. The order of magnitude of the total personal income (in dollars) for Montana in 2003 was 10^{10} . What was the order of magnitude of the mean personal income in Montana in 2003? 10^4

8.3 Define and Use Zero and Negative Exponents

pp. 503–508

EXAMPLE

Evaluate $(2x^0y^{-5})^3$.

$$(2x^0y^{-5})^3 = 2^3 \cdot x^0 \cdot y^{-15}$$

Power of a power property

$$= 8 \cdot 1 \cdot y^{-15}$$

Definition of zero exponent

$$= \frac{8}{y^{15}}$$

Definition of negative exponents

EXAMPLES

1, 2, and 4
on pp. 503–505
for Exs. 25–29

EXERCISES

Evaluate the expression.

25. 14^0

1

26. $3^{-4} \frac{1}{81}$

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

28. $7^{-5} \cdot 7^5$

29. **UNITS OF MEASURE** Use the fact that 1 femtogram = 10^{-16} kilogram and 1 nanogram = 10^{-12} kilogram to complete the following statement:
1 nanogram = ? femtogram(s). 10^6

8.4 Use Scientific Notation

pp. 512–518

EXAMPLE

Write the number in scientific notation.

- a. $2097 = 2.097 \times 10^3$ Move decimal point left 3 places. Exponent is 3.
 b. $0.00032 = 3.2 \times 10^{-4}$ Move decimal point right 4 places. Exponent is -4 .

Write the number in standard form.

- a. $4.3201 \times 10^2 = 432.01$ Exponent is 2. Move decimal point right 2 places.
 b. $2.068 \times 10^{-3} = 0.002068$ Exponent is -3 . Move decimal point left 3 places.

EXERCISES

30. Write 78,120 in scientific notation. 7.812×10^4 31. Write 7.5×10^{-5} in standard form. 0.000075

Evaluate the expression. Write your answer in scientific notation.

32. $(6.3 \times 10^3)(1.9 \times 10^{-5})$ 1.197×10^{-1} 33. $\frac{6.5 \times 10^9}{1.6 \times 10^{-4}}$ 4.0625×10^{13}

34. **MASS** The mass m_1 of a gate of the Thames Barrier in London is about 1.5×10^6 kilograms. The mass m_2 of the Great Pyramid of Giza is about 6×10^9 kilograms. Find the ratio of m_1 to m_2 . What does the ratio tell you? 2.5×10^{-4} ; the pyramid has a mass 25,000 times the mass of the gate.

EXAMPLES
1, 2, 4, and 5
on pp. 512–514
for Exs. 30–34

8.5 Write and Graph Exponential Growth Functions

pp. 520–527

EXAMPLE

Graph the function $y = 4^x$ and identify its domain and range.

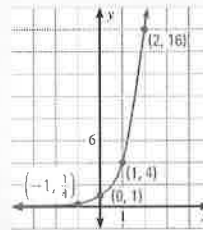
STEP 1 Make a table. The domain is all real numbers.

x	-1	0	1	2
y	$\frac{1}{4}$	1	4	16

STEP 2 Plot the points.

STEP 3 Draw a smooth curve through the points.

STEP 4 Identify the range. As you can see from the graph, the range is all positive real numbers.



EXERCISES

Graph the function and identify its domain and range. 35–38. See margin.

35. $y = 6^x$ 36. $y = (1.1)^x$ 37. $y = (3.5)^x$ 38. $y = \left(\frac{5}{2}\right)^x$

39. Graph the function $y = -5 \cdot 2^x$. Compare the graph with the graph of $y = 2^x$. See margin.

EXAMPLES
2 and 3
on p. 521
for Exs. 35–39

Extra Example 8.4

Write the number in scientific notation.

- a. 463,250 4.6325×10^5
 b. 0.3457 3.457×10^{-1}

Write the number in standard form.

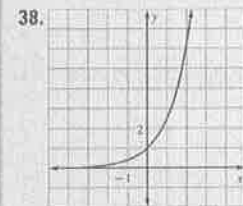
- a. 5.23×10^4 52,300
 b. 9.021×10^{-6} 0.000009021

Extra Example 8.5

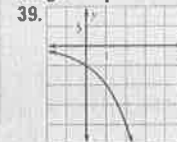
Graph the function $y = \left(\frac{5}{2}\right)^x$ and identify its domain and range.



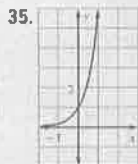
domain: all real numbers;
range: all positive real numbers



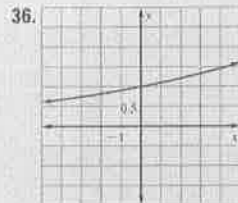
domain: all real numbers,
range: all positive real numbers



The graph is a vertical stretch with a reflection in the x -axis.



domain: all real numbers,
range: all positive real numbers



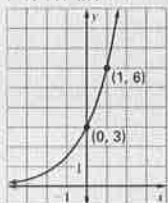
domain: all real numbers,
range: all positive real numbers



domain: all real numbers,
range: all positive real numbers

Extra Examples 8.6

1. Tell whether the graph represents exponential growth or exponential decay. Then write a rule for the function.



The graph represents exponential growth. A function rule is $y = 3(2)^x$.

2. A high school issued a report that enrollment in physical education classes at their school has been declining at a rate of 6% per year since 1984. For all grades at the high school, enrollment in physical education classes was 2864 in 1984. Write a function that models the enrollment over time. Find the approximate number of students enrolled in physical education in 2006. $y = 2864(1 - 0.06)^t$; There were about 734 students enrolled in physical education classes at the high school in 2006.

42. Let V represent the value of the car (in dollars) and x represent the number of years since the initial value. $V = 13,000(0.85)^x$; about \$6786.

EXAMPLES
4 and 5
on pp. 533–534
for Exs. 40–42

8.6 Write and Graph Exponential Decay Functions

pp. 531–538

EXAMPLE 1

Tell whether the graph represents *exponential growth* or *exponential decay*. Then write a rule for the function.

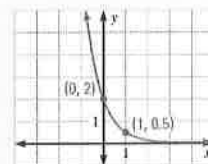
The graph represents exponential decay ($y = ab^x$ where $0 < b < 1$). The y -intercept is 2, so $a = 2$. Find the value of b by using the point $(1, 0.5)$ and $a = 2$.

$$y = ab^x \quad \text{Write function.}$$

$$0.5 = 2 \cdot b^1 \quad \text{Substitute.}$$

$$0.25 = b \quad \text{Solve for } b.$$

A function rule is $y = 2(0.25)^x$.



EXAMPLE 2

CAR VALUE A family purchases a car for \$11,000. The car depreciates (loses value) at a rate of about 16% annually. Write a function that models the value of the car over time. Find the approximate value of the car in 4 years.

Let V represent the value (in dollars) of the car, and let t represent the time (in years since the car was purchased). The initial value is 11,000, and the decay rate is 0.16.

$$V = a(1 - r)^t \quad \text{Write exponential decay model.}$$

$$= 11,000(1 - 0.16)^t \quad \text{Substitute 11,000 for } a \text{ and 0.16 for } r.$$

$$= 11,000(0.84)^t \quad \text{Simplify.}$$

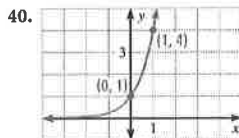
To find the approximate value of the car in 4 years, substitute 4 for t .

$$V = 11,000(0.84)^4 = 11,000(0.84)^4 \approx \$5477$$

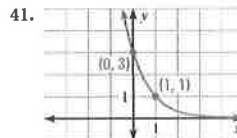
The approximate value of the car in 4 years is \$5477.

EXERCISES

Tell whether the graph represents *exponential growth* or *exponential decay*. Then write a rule for the function.



exponential growth; $y = 4^x$



exponential decay;
 $y = 3 \cdot \left(\frac{1}{3}\right)^x$

42. **CAR VALUE** The value of a car is \$13,000. The car depreciates (loses value) at a rate of about 15% annually. Write an exponential decay model for the value of the car. Find the approximate value of the car in 4 years. See margin.

Simplify the expression. Write your answer using exponents.

1. $(62 \cdot 17)^4 \cdot 62^4 \cdot 17^4$ 2. $(-3)(-3)^6 (-3)^7$ 3. $\frac{8^4 \cdot 8^5}{8^3} \cdot 8^6$ 4. $(8^4)^3 \cdot 8^{12}$
 5. $\frac{2^{15}}{2^8} \cdot 2^7$ 6. $5^3 \cdot 5^0 \cdot 5^5 \cdot 5^8$ 7. $[(-4^3)]^2 (-4)^6$ 8. $\frac{(-5)^{10}}{(-5)^3} (-5)^7$

Simplify the expression.

9. $t^2 \cdot t^6 \cdot t^8$ 10. $\left(\frac{s}{t}\right)^6 \cdot \frac{s^6}{t^6}$ 11. $\frac{1}{9^{-2}} \cdot 81$ 12. $-(6p)^2 - 36p^2$
 13. $(5xy)^2 \cdot 25x^2y^2$ 14. $\frac{1}{z^7} \cdot z^9 \cdot z^2$ 15. $(x^5)^3 \cdot x^{15}$ 16. $\left(-\frac{4}{c}\right)^2 \cdot \frac{16}{c^2}$

Simplify the expression. Write your answer using only positive exponents.

17. $\left(\frac{a^{-3}}{3b}\right)^4 \cdot \frac{1}{81a^{12}b^4}$ 18. $\frac{3}{4d} \cdot \frac{(2d)^4}{c^3} \cdot \frac{12d^3}{c^3}$ 19. $y^0 \cdot (8x^6y^{-3})^{-2} \cdot \frac{y^6}{64x^{12}}$ 20. $(5r^5)^3 \cdot r^{-2} \cdot 125r^{13}$

Write the number in scientific notation.

21. 423.6 22. 7,194,548 23. 500.32 24. 71.23884
 4.236×10^2 7.194548×10^6 5.0032×10^2 7.123884×10^1
 25. 0.562 26. 0.0348 27. 0.000123 28. 0.5603002
 5.62×10^{-1} 3.48×10^{-2} 1.23×10^{-4} 5.603002×10^{-1}

Write the number in standard form.

29. 4.02×10^5 30. 5.3121×10^4 31. 9.354×10^8 32. 1.307×10^{19}
 402,000 53,121 935,400,000 See margin.
 33. 1.3×10^{-3} 34. 3.32×10^{-4} 35. 7.506×10^{-5} 36. 9.3119×10^{-7}
 0.0013 0.000332 0.00007506 0.00000093119

37. Graph the function $y = 4^x$. Identify its domain and range. See margin.

38. Graph the function $y = \frac{1}{2} \cdot 4^x$. Compare the graph with the graph of $y = 4^x$. See margin.

39. **ANIMATION** About 1.2×10^7 bytes of data make up a single frame of an animated film. There are 24 frames in 1 second of a film. About how many bytes of data are there in 1 hour of an animated film? about 1.04×10^{12} bytes

40. **SALARY** A recent college graduate accepts a job at a law firm. The job has a salary of \$32,000 per year. The law firm guarantees an annual pay increase of 3% of the employee's salary.

- a. Write a function that models the employee's salary over time. Assume that the employee receives only the guaranteed pay increase. See margin.
 b. Use the function to find the employee's salary after 5 years. \$37,096.77

41. **SCIENCE** At sea level, Earth's atmosphere exerts a pressure of 1 atmosphere. Atmospheric pressure P (in atmospheres) decreases with altitude and can be modeled by $P = (0.99987)^a$ where a is the altitude (in meters).

- initial amount: 1, decay factor: 0.99987, decay rate: 0.013%
 a. Identify the initial amount, decay factor, and decay rate.
 b. Use a graphing calculator to graph the function. See margin.
 c. Estimate the altitude at which the atmospheric pressure is about half of what it is at sea level. about 5332 m

Chapter Test 547

Additional Resources

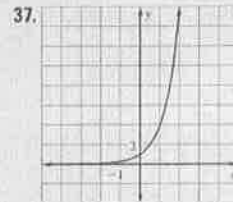
Assessment Book

- Chapter Test, Levels A, B, C, pp. 112–117
- Standardized Chapter Test, pp. 118–119
- SAT/ACT Chapter Test, pp. 120–121
- Alternative Assessment, pp. 122–123

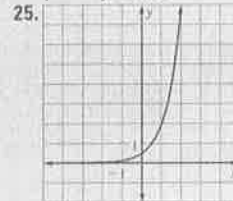
Test Generator CD-ROM

Chapter Test

Easily-readable reduced copies (with answers) of Chapter Test B, the Standardized Chapter Test, and the Alternative Assessment from the Assessment Book can be found on pp. 486E–486F.



domain: all real numbers,
range: all positive real numbers



The graph is a vertical shrink of $y = 4^x$.

40a. Let y represent the yearly salary and x represent the number of years since accepting the job. $y = 32,000(1.03)^x$.

