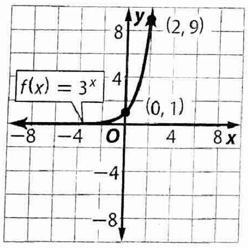
covered by the questions, remind students that the page references tell them where to review that topic in their textbook.

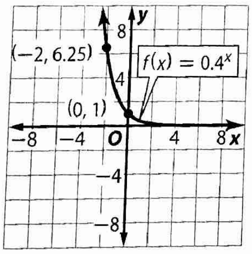
Two-Day Option Have students complete the Lesson-by-Lesson Review on pp. 212–214. Then you can use McGraw-Hill eAssessment to customize another review worksheet that practices all the objectives of this chapter or only the objectives on which your students need more help.

Additional Answers

11. D = $(-\infty, \infty)$; R = $(0, \infty)$; y-intercept: 1; asymptote: x-axis; $\lim_{x\to-\infty} f(x) = 0$, $\lim_{x\to\infty} f(x) = \infty$; increasing for $(-\infty, \infty)$



12. D = $(-\infty, \infty)$; R = $(0, \infty)$; y-intercept: 1; asymptote: x-axis; $\lim_{x\to-\infty} f(x) = \infty$, $\lim_{x\to\infty} f(x) = 0$; decreasing on $(-\infty, \infty)$



Lesson-by-Lesson Review

3-1 Exponential Functions (pp. 158–169)

Sketch and analyze the graph of each function. Describe its domain, range, intercepts, asymptotes, end behavior, and where the function is increasing or decreasing.

11. $f(x) = 3^x$ **12.** $f(x) = 0.4^x$

13. $f(x) = \left(\frac{3}{2}\right)^x$ **14.** $f(x) = \left(\frac{1}{3}\right)^x$

11–14. See margin.

Use the graph of $f(x)$ to describe the transformation that results in the graph of $g(x)$. Then sketch the graphs of $f(x)$ and $g(x)$.

15. $f(x) = 4^x$; $g(x) = 4^x + 2$

16. $f(x) = 0.1^x$; $g(x) = 0.1^{x-3}$

17. $f(x) = 3^x$; $g(x) = 2 \cdot 3^x - 5$

18. $f(x) = \left(\frac{1}{2}\right)^x$; $g(x) = \left(\frac{1}{2}\right)^{x+4} + 2$

15–18. See Chapter 3 Answer Appendix.

Copy and complete the table below to find the value of an investment A for the given principal P, rate r, and time t if the interest is compounded n times annually.

n	1	4	12	365	continuously
A					

19. $P = \$250$, $r = 7\%$, $t = 6$ years

20. $P = \$1000$, $r = 4.5\%$, $t = 3$ years

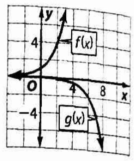
19–20. See Chapter 3 Answer Appendix.

Example 1

Use the graph of $f(x) = 2^x$ to describe the transformation that results in the graph of $g(x) = -2^{x-5}$. Then sketch the graphs of g and f.

This function is of the form $g(x) = -f(x - 5)$.

So, $g(x)$ is the graph of $f(x) = 2^x$ translated 5 units to the right and reflected in the x-axis.



Example 2

What is the value of $2000 invested at 6.5% after 12 years if the interest is compounded quarterly? continuously?

$A = P\left(1 + \frac{r}{n}\right)^{nt}$ Compound Interest Formula

$= 2000\left(1 + \frac{0.065}{4}\right)^{4(12)}$ $P = 2000$, $r = 0.065$, $n = 4$, $t = 12$

$= \$4335.68$ Simplify.

$A = Pe^{rt}$ Continuous Interest Formula

$= 2000e^{0.065(12)}$ $P = 2000$, $r = 0.065$, $t = 12$

$= \$4362.94$ Simplify.

3-2 Logarithmic Functions (pp. 172–180)

Evaluate each expression.

21. $\log_2 32$ 5

22. $\log_3 \frac{1}{81}$ −4

23. $\log_{25} 5$ $\frac{1}{2}$

24. $\log_{13} 1$ 0

25. $\ln e^{11}$ 11

26. $3^{\log_3 9}$ 9

27. $\log 80$ about 1.90

28. $e^{\ln 12}$ 12

Use the graph of $f(x)$ to describe the transformation that results in the graph of $g(x)$. Then sketch the graphs of $f(x)$ and $g(x)$.

29. $f(x) = \log x$; $g(x) = -\log(x + 4)$

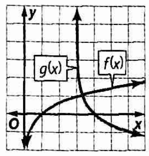
30. $f(x) = \log_2 x$; $g(x) = \log_2 x + 3$

31. $f(x) = \ln x$; $g(x) = \frac{1}{4}\ln x - 2$

29–31. Chapter 3 Answer Appendix.

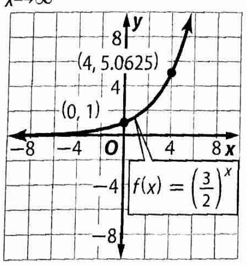
Use the graph of $f(x) = \ln x$ to describe the transformation that results in the graph of $g(x) = -\ln(x - 3)$. Then sketch the graphs of $g(x)$ and $f(x)$.

This function is of the form $g(x) = -f(x - 3)$. So, $g(x)$ is the graph of $f(x)$ reflected in the x-axis translated 3 units to the right.

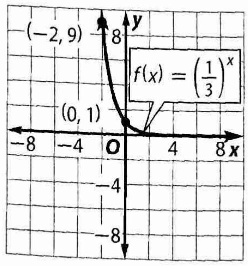


212 | Chapter 3 | Study Guide and Review

13. D = $(-\infty, \infty)$; R = $(0, \infty)$; y-intercept: 1; asymptote: x-axis; $\lim_{x\to-\infty} f(x) = 0$, $\lim_{x\to\infty} f(x) = \infty$; increasing on $(-\infty, \infty)$



14. D = $(-\infty, \infty)$; R = $(0, \infty)$; y-intercept: 1; asymptote: x-axis; $\lim_{x\to-\infty} f(x) = \infty$, $\lim_{x\to\infty} f(x) = 0$; decreasing on $(-\infty, \infty)$



3-3 Properties of Logarithms (pp. 181–188)

Expand each expression.

32. $\log_3 9x^3y^3z^6$ **$2 + 3\log_3 x + 3\log_3 y + 6\log_3 z$**

33. $\log_5 x^2a^7\sqrt{b}$ **$2\log_5 x + 7\log_5 a + \frac{1}{2}\log_5 b$**

34. $\ln \frac{e}{x^2y^3z}$ **$1 - 2\ln x - 3\ln y - \ln z$**

35. $\log \frac{\sqrt{gj^5k}}{100}$ **$\frac{1}{2}(\log g + 5\log j + \log k) - 2$**

Condense each expression.

36. $3\log_3 x - 2\log_3 y$ **$\log_3 \frac{x^3}{y^2}$**

37. $\frac{1}{3}\log_2 a + \log_2 (b + 1)$ **$\log_2 [\sqrt[3]{a}(b + 1)]$**

38. $5\ln(x + 3) + 3\ln 2x - 4\ln(x - 1)$ **$\ln \frac{8x^3(x + 3)^5}{(x - 1)^4}$**

Example 4

Condense $3\log_3 x + \log_3 7 - \frac{1}{2}\log_3 x$.

$3\log_3 x + \log_3 7 - \frac{1}{2}\log_3 x$

$= \log_3 x^3 + \log_3 7 - \log_3\sqrt{x}$	Power Property
$= \log_3 7x^3 - \log_3\sqrt{x}$	Product Property
$= \log_3 \frac{7x^3}{\sqrt{x}}$	Quotient Property

3-4 Exponential and Logarithmic Equations (pp. 190–199)

Solve each equation.

39. $3^{x+3} = 27^{x-2}$ **$\frac{9}{2}$**

40. $25^{3x+2} = 125$ **$-\frac{1}{6}$**

41. $e^{2x} - 8e^x + 15 = 0$ **$\ln 3; \ln 5$**

42. $e^x - 4e^{-x} = 0$ **$\ln 2$**

43. $\log_2 x + \log_2 3 = \log_2 18$ **6**

44. $\log_6 x + \log_6 (x - 5) = 2$ **9**

Example 5

Solve $7\ln 2x = 28$.

$7\ln 2x = 28$	Original equation
$\ln 2x = 4$	Divide each side by 7.
$e^{\ln 2x} = e^4$	Exponentiate each side.
$2x = e^4$	Inverse Property
$x = 0.5e^4$ or about 27.299	Solve and simplify.

3-5 Modeling With Nonlinear Regression (pp. 200–210)

Complete each step.

a. Linearize the data according to the given model.
b. Graph the linearized data, and find the linear regression equation.
c. Use the linear model to find a model for the original data and graph it.

45. exponential **45–46. See margin.**

x	0	1	2	3	4	5	6
y	2	5	17	53	166	517	1614

46. logarithmic

x	1	2	3	4	5	6	7
y	−3	4	8	10	12	14	15

Example 6

Linearize the data shown assuming a logarithmic model, and calculate the equation for the line of best fit. Use this equation to find a logarithmic model for the original data.

x	1	3	5	7	9	10
y	12	−7	−15	−21	−25	−27

Step 1 To linearize $y = a\ln x + b$, graph $(\ln x, y)$.

$\ln x$	0	1.1	1.6	1.9	2.2	2.3
y	12	−7	−15	−21	−25	−27

Step 2 The line of best fit is $y = -16.94x + 11.86$.

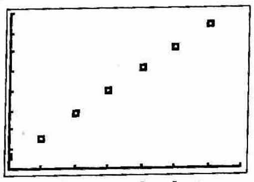
Step 3 $y = -16.94\ln x + 11.86$ $\quad x = \ln x$

Additional Answers

45a.

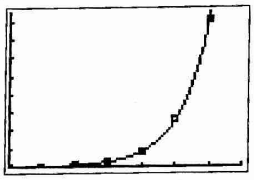
x	0	1	2	3	4	5	6
$\ln y$	0.69	1.61	2.83	3.97	5.11	6.25	7.39

45b. $\hat{y} = 1.13x + 0.59$



[0, 7] scl: 1 by [0, 8] scl: 1

45c. $y = 1.80e^{1.13x}$

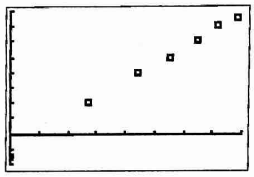


[0, 7] scl: 1 by [0, 1700] scl: 200

46a.

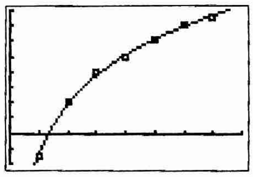
$\ln x$	0	0.69	1.10	1.39	1.61	1.79	1.95
y	−3	4	8	10	12	14	15

46b. $y = 9.2\hat{x} - 2.66$



[0, 2] scl: 0.25 by [−4, 16] scl: 2

46c. $y = 9.2\ln x - 2.66$



[0, 8] scl: 1 by [−4, 16] scl: 2

connectED.mcgraw-hill.com 213

Anticipation Guide

Have students complete the Chapter 3 Anticipation Guide and discuss how their responses have changed now that they have completed the chapter.

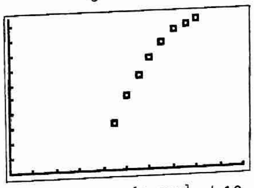
Before the Test

Have students complete pp. 47 and 48 of the Study Notebook to review topics and skills presented in the chapter.

Additional Answers

52b. No; sample answer: Doubling the intensity does not double the decibels; $10 \log \frac{2w}{w_0} = 10 \log 2 + 10 \log \frac{w}{w_0} \neq 2 \cdot 10 \log \frac{w}{w_0}$.

54a.

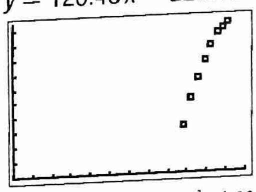


[0, 20] scl: 2 by [0, 105] scl: 10

54b.

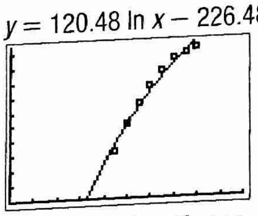
ln x	2.20	2.30	2.40	2.48	2.56	2.64	2.71	2.77
y	33	50	65	77	87	94	98	101

54c. $y = 120.48\hat{x} - 226.48$



[0, 3] scl: 0.25 by [0, 105] scl: 10

54d. $y = 120.48 \ln x - 226.48$



[0, 20] scl: 2 by [0, 105] scl: 10

Applications and Problem Solving

47. INFLATION Prices of consumer goods generally increase each year due to inflation. From 2000 to 2008, the average rate of inflation in the United States was 4.5%. At this rate, the price of milk t years after January 2000 can be modeled with $M(t) = 2.75(1.045)^t$. (Lesson 3-1)

a. What was the price of milk in 2000? 2005? **\$2.75; \$3.43**

b. If inflation continues at 4.5%, approximately what will the price of milk be in 2015? **\$5.32**

c. In what year did the price of milk reach \$4? **2008**

48. CARS The value of a new vehicle depreciates the moment the car is driven off the dealer's lot. The value of the car will continue to depreciate every year. The value of one car t years after being bought is $f(x) = 18{,}000(0.8)^t$. (Lesson 3-1)

a. What is the rate of depreciation for the car? **20%**

b. How many years after the car is bought will it be worth half of its original value? **3.11 yr**

49. CHEMISTRY A radioactive substance has a half-life of 16 years. The number of years t it takes to decay from an initial amount N_0 to N can be determined using $t = \frac{16 \log \frac{N}{N_0}}{\log \frac{1}{2}}$. (Lesson 3-2)

a. Approximately how many years will it take 100 grams to decay to 30 grams? **28 yr**

b. Approximately what percentage of 100 grams will there be in 40 years? **18%**

50. EARTHQUAKES The Richter scale is a number system for determining the strength of earthquakes. The number R is dependent on energy E released by the earthquake in kilowatt-hours. The value of R is determined by $R = 0.67 \cdot \log(0.37E) + 1.46$. (Lesson 3-2)

a. Find R for an earthquake that releases 1,000,000 kilowatt-hours. **5.2**

b. Estimate the energy released by an earthquake that registers 7.5 on the Richter scale. **2.8×10^9 kWh**

51. BIOLOGY The time it takes for a species of animal to double is defined as its *generation time* and is given by $G = \frac{t}{2.5 \log_b d}$, where b is the initial number of animals, d is the final number of animals, t is the time period, and G is the generation time. If the generation time G of a species is 6 years, how much time t will it take for 5 animals to grow into a population of 3125 animals? (Lesson 3-3) **75 yr**

52. SOUND The intensity level of a sound, measured in decibels, can be modeled by $d(w) = 10 \log \frac{w}{w_0}$, where w is the intensity of the sound in watts per square meter and w_0 is the constant 1×10^{-12} watts per square meter. (Lesson 3-4)

a. Determine the intensity of the sound at a concert that reaches 100 decibels. **1×10^{-2}**

b. Tory compares the concert with the music she plays at home. She plays her music at 50 decibels, so the intensity of her music is half the intensity of the concert. Is her reasoning correct? Justify your answer mathematically. **See margin.**

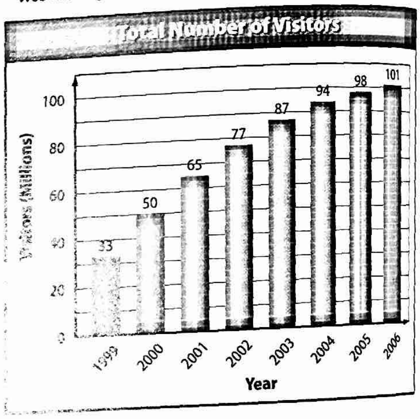
c. Soft music is playing with an intensity of 1×10^{-8} watts per square meter. By how much do the decimals increase if the intensity is doubled? **3.01 dB**

53. FINANCIAL LITERACY Delsin has \$8000 and wants to put it into an interest-bearing account that compounds continuously. His goal is to have \$12,000 in 5 years. (Lesson 3-4)

a. Delsin found a bank that is offering 6% on investments. How long would it take his investment to reach \$12,000 at 6%? **about 6.76 yr**

b. What rate does Delsin need to invest at to reach his goal of \$12,000 after 5 years? **about 8.1%**

54. INTERNET The number of people to visit a popular Web site is given below. (Lesson 3-5) **a–d. See margin.**



a. Make a scatterplot of the data. Let 1990 = 0.

b. Linearize the data with a logarithmic model.

c. Graph the linearized data, and find the linear regression equation.

d. Use the linear model to find a model for the original data and graph it.

CHAPTER 3 Practice Test

Sketch and analyze the graph of each function. Describe its domain, range, intercepts, asymptotes, end behavior, and where the function is increasing or decreasing.

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

1–2. See margin.

Use the graph of $f(x)$ to describe the transformation that results in the graph of $g(x)$. Then sketch the graphs of $f(x)$ and $g(x)$.

3. $f(x) = \left(\frac{1}{2}\right)^x$ $\quad g(x) = \left(\frac{1}{2}\right)^{x-3} + 4$
4. $f(x) = 5^x$ $\quad g(x) = -5^{-x} - 2$

3–4. See Chapter 3 Answer Appendix.

5. **MULTIPLE CHOICE** For which function is $\lim_{x \to \infty} f(x) = -\infty$? **C**
   - **A** $f(x) = -2 \cdot 3^{-x}$
   - **B** $f(x) = -\left(\frac{1}{10}\right)^x$
   - **C** $f(x) = -\log_8 (x - 5)$
   - **D** $f(x) = \log_3 (-x) - 6$

Evaluate each expression.

6. $\log_3 \frac{1}{81}$ **−4**
7. $\log_{32} 2$ $\frac{1}{5}$
8. $\log 10^{12}$ **12**
9. $9^{\log_9 5.3}$ **5.3**

Sketch the graph of each function. **10–11. See margin.**

10. $f(x) = -\log_4 (x + 3)$
11. $g(x) = \log (-x) + 5$

12. **FINANCIAL LITERACY** You invest $1500 in an account with an interest rate of 8% for 12 years, making no other deposits or withdrawals.
    - a. What will be your account balance if the interest is compounded monthly? **$3905.08**
    - b. What will be your account balance if the interest is compounded continuously? **$3917.54**
    - c. If your investment is compounded daily, about how long will it take for it to be worth double the initial amount? **about 8.67 yr**

Expand each expression.

13. $\log_6 36xy^2$ $\quad 2 + \log_6 x + 2 \log_6 y$
14. $\log_3 \frac{a\sqrt{b}}{12}$ $\quad$ **14.** $\log_3 a + \frac{1}{2} \log_3 b - \log_3 4 - 1$

15. **GEOLOGY** Richter scale magnitude of an earthquake can be calculated using $R = \frac{2}{3} \log \frac{E}{E_0}$, where E is the energy produced and E_0 is a constant.
    - a. An earthquake with a magnitude of 7.1 hit San Francisco in 1989. Find the scale of an earthquake that produces 10 times the energy of the 1989 earthquake. **7.8**
    - b. In 1906, San Francisco had an earthquake registering 8.25. How many times as much energy did the 1906 earthquake produce as the 1989 earthquake? **about 53 times as large**

Condense each expression.

16. $2 \log_4 m + 6 \log_4 n - 3(\log_4 3 + \log_4 j)$ $\quad \log_4 \frac{m^2n^6}{27j^3}$
17. $1 + \ln 3 - 4 \ln x$ $\quad \ln \frac{3e}{x^4}$

Solve each equation.

18. $3^{x+8} = 9^{2x}$ $\quad \frac{8}{3}$
19. $e^{2x} - 3e^x + 2 = 0$ $\quad 0, \ln 2$
20. $\log x + \log (x - 3) = 1$ $\quad 5$
21. $\log_2 (x - 1) + 1 = \log_2 (x + 3)$ $\quad 5$

22. **MULTIPLE CHOICE** Which equation has no solution? **J**
    - **F** $e^x = e^{-x}$
    - **G** $2^{x-1} = 3^{x+1}$
    - **H** $\log_5 x = \log_9 x$
    - **J** $\log_2 (x + 1) = \log_2 x$

For Exercises 23 and 24, complete each step.

a. Find an exponential or logarithmic function to model the data.
b. Find the value of each model at $x = 20$.

23.

[illegible]	1	3	5	7	9	11	13
[illegible]	8	3	0	−2	−3	−4	−5

a. $f(x) = 8.20 - 5.11 \ln x$ $\quad$ **b.** −7.11

24.

[illegible]	1	3	5	7	9	11	13
[illegible]	3	4	5	6	7	9	10

a. $f(x) = 2.9(1.1)^x$ $\quad$ **b.** 21.22

25. **CENSUS** The table gives the U.S. population between 1790 and 1940. Let 1780 = 0.

[illegible]	[illegible]
1790	4
1820	10
1850	23
1880	50
1910	92
1940	132

a. Linearize the data, assuming a quadratic model. Graph the data, and write an equation for a line of best fit.
b. Use the linear model to find a model for the original data. Is a quadratic model a good representation of population growth? Explain.

a–b. See Chapter 3 Answer Appendix.

connectED.mcgraw-hill.com **215**

InterventionPlanner

TIER 1 On Level OL

If students miss about 25% of the exercises or less,

Then choose a resource:

- SE Lessons 3-1, 3-2, 3-3, 3-4, and 3-5
- TE Chapter Project, p. 156
- connectED.mcgraw-hill.com Self-Check Quiz

TIER 2 Strategic Intervention AL approaching grade level

If students miss about 50% of the exercises,

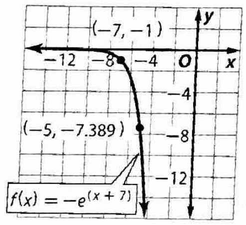
Then choose a resource:

- Study Guide and Intervention, Chapter 3, pp. 5, 10, 15, 20, and 26
- connectED.mcgraw-hill.com Extra Examples, Homework Help

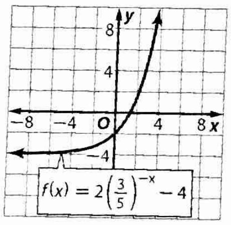
McGraw-Hill eAssessment Customize and create multiple versions of your chapter test and their answer keys. All of the questions from the leveled chapter tests in the *Chapter 3 Resource Masters* are also available on McGraw-Hill eAssessment.

Additional Answers

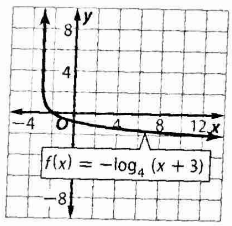
1. $D = (-\infty, \infty)$; $R = (-\infty, 0)$; y-intercept: $-e^7$; asymptote: x-axis; $\lim_{x \to -\infty} f(x) = 0$, $\lim_{x \to \infty} f(x) = -\infty$ decreasing for $(-\infty, \infty)$



2. $D = (-\infty, \infty)$; $R = (-4, \infty)$; y-intercept: -2; x-intercept: 1.36; asymptote: $y = -4$; $\lim_{x \to -\infty} f(x) = -4$; $\lim_{x \to \infty} f(x) = \infty$ increasing for $(-\infty, \infty)$



10.



11.