SECTION 3.3 EXERCISES

In Exercises 1–18, evaluate the logarithmic expression without using a calculator.

1. $\log_4 4$
2. $\log_6 1$
3. $\log_2 32$
4. $\log_3 81$
5. $\log_5 \sqrt[3]{25}$
6. $\log_6 \frac{1}{\sqrt[5]{36}}$
7. $\log 10^3$
8. $\log 10{,}000$
9. $\log 100{,}000$
10. $\log 10^{-4}$
11. $\log \sqrt[3]{10}$
12. $\log \frac{1}{\sqrt{1000}}$
13. $\ln e^3$
14. $\ln e^{-4}$
15. $\ln \frac{1}{e}$
16. $\ln 1$
17. $\ln \sqrt[4]{e}$
18. $\ln \frac{1}{\sqrt{e^7}}$

In Exercises 19–24, evaluate the expression without using a calculator.

19. $7^{\log_7 3}$
20. $5^{\log_5 8}$
21. $10^{\log(0.5)}$
22. $10^{\log 14}$
23. $e^{\ln 6}$
24. $e^{\ln(1/5)}$

In Exercises 25–32, use a calculator to evaluate the logarithmic expression if it is defined, and check your result by evaluating the corresponding exponential expression.

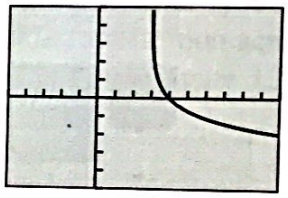
25. $\log 9.43$
26. $\log 0.908$
27. $\log(-14)$
28. $\log(-5.14)$
29. $\ln 4.05$
30. $\ln 0.733$
31. $\ln(-0.49)$
32. $\ln(-3.3)$

In Exercises 33–36, solve the equation by changing it to exponential form.

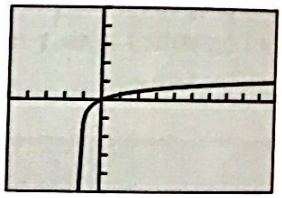
33. $\log x = 2$
34. $\log x = 4$
35. $\log x = -1$
36. $\log x = -3$

In Exercises 37–40, match the function with its graph.

37. $f(x) = \log(1 - x)$
38. $f(x) = \log(x + 1)$
39. $f(x) = -\ln(x - 3)$
40. $f(x) = -\ln(4 - x)$



(a)



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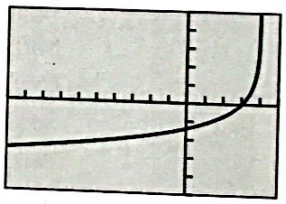

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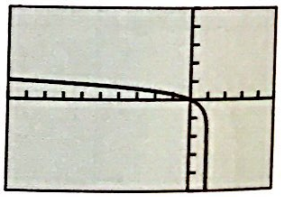


(d)

In Exercises 41–46, describe how to transform the graph of $y = \ln x$ into the graph of the given function. Sketch the graph by hand and support with a grapher.

41. $f(x) = \ln(x + 3)$
42. $f(x) = \ln(x) + 2$
43. $f(x) = \ln(-x) + 3$
44. $f(x) = \ln(-x) - 2$
45. $f(x) = \ln(2 - x)$
46. $f(x) = \ln(5 - x)$

In Exercises 47–52, describe how to transform the graph of $y = \log x$ into the graph of the given function. Sketch the graph by hand and support with a grapher.

47. $f(x) = -1 + \log(x)$
48. $f(x) = \log(x - 3)$
49. $f(x) = -2\log(-x)$
50. $f(x) = -3\log(-x)$
51. $f(x) = 2\log(3 - x) - 1$
52. $f(x) = -3\log(1 - x) + 1$

In Exercises 53–58, graph the function, and analyze it for domain, range, continuity, increasing or decreasing behavior, boundedness, extrema, symmetry, asymptotes, and end behavior.

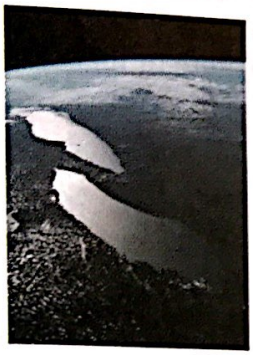
53. $f(x) = \log(x - 2)$
54. $f(x) = \ln(x + 1)$
55. $f(x) = -\ln(x - 1)$
56. $f(x) = -\log(x + 2)$
57. $f(x) = 3\log(x) - 1$
58. $f(x) = 5\ln(2 - x) - 3$

59. **Sound Intensity** Use the data in Table 3.17 to compute the sound intensity in decibels for **(a)** a soft whisper, **(b)** city traffic, and **(c)** a jet at takeoff.

60. **Light Absorption** The Beer-Lambert law of absorption applied to Lake Erie states that the light intensity I (in lumens), at a depth of x feet, satisfies the equation

$$\log \frac{I}{12} = -0.00235x.$$

Find the intensity of the light at a depth of 30 ft.



61. **Algerian Oil Production** Find a natural logarithmic regression equation for the data in Table 3.18. Use it to estimate production for the year 1980. Use 1950 as $t = 0$.

TABLE 3.18 ALGERIAN OIL PRODUCTION

Year	Metric Tons
1960	8.63
1970	47.25
1990	56.67

Source: The Statesman's Yearbook, 129th ed. (London: The Macmillan Press, Ltd., 1992).

62. **Canadian Oil Production** Find a natural logarithmic regression equation for the data in Table 3.19. Use it to estimate production for the year 1985. Use 1950 as $t = 0$.

TABLE 3.19 CANADIAN OIL PRODUCTION

Year	Metric Tons
1960	27.48
1970	69.95
1990	92.24

Source: The Statesman's Yearbook, 129th ed. (London: The Macmillan Press, Ltd., 1992).

Standardized Test Questions

63. **True or False** A logarithmic function is the inverse of an exponential function. Justify your answer.

64. **True or False** Common logarithms are logarithms with base 10. Justify your answer.

In Exercises 65–68, you may use a graphing calculator to solve the problem.

65. **Multiple Choice** What is the approximate value of the common log of 2?

(a) 0.10523 **(b)** 0.20000
(c) 0.30103 **(d)** 0.69315
(e) 3.32193

66. **Multiple Choice** Which statement is false?

(a) $\log 5 = 2.5 \log 2$ **(b)** $\log 5 = 1 - \log 2$
(c) $\log 5 > \log 2$ **(d)** $\log 5 < \log 10$
(e) $\log 5 = \log 10 - \log 2$

67. **Multiple Choice** Which statement is **false** about $f(x) = \ln x$?

(a) It is increasing on its domain.
(b) It is symmetric about the origin.
(c) It is continuous on its domain.
(d) It is unbounded.
(e) It has a vertical asymptote.

68. **Multiple Choice** Which of the following is the inverse of $f(x) = 2 \cdot 3^x$?

(a) $f^{-1}(x) = \log_3(x/2)$ **(b)** $f^{-1}(x) = \log_2(x/3)$
(c) $f^{-1}(x) = 2\log_3(x)$ **(d)** $f^{-1}(x) = 3\log_2(x)$
(e) $f^{-1}(x) = 0.5\log_3(x)$

Explorations

69. **Writing to Learn Parametric Graphing** In the manner of Exploration 1, make tables and graphs for $f(x) = 3^x$ and its inverse $f^{-1}(x) = \log_3 x$. Write a comparative analysis of the two functions regarding domain, range, intercepts, and asymptotes.

70. **Writing to Learn Parametric Graphing** In the manner of Exploration 1, make tables and graphs for $f(x) = 5^x$ and its inverse $f^{-1}(x) = \log_5 x$. Write a comparative analysis of the two functions regarding domain, range, intercepts, and asymptotes.

71. **Group Activity Parametric Graphing** In the manner of Exploration 1, find the number $b > 1$ such that the graphs of $f(x) = b^x$ and its inverse $f^{-1}(x) = \log_b x$ have exactly one point of intersection. What is the one point that is in common to the two graphs?

72. **Writing to Learn** Explain why zero is not in the domain of the logarithmic functions $y = \log_3 x$ and $y = \log_5 x$.

Extending the Ideas

73. Describe how to transform the graph of $f(x) = \ln x$ into the graph of $g(x) = \log_{1/e} x$.

74. Describe how to transform the graph of $f(x) = \log x$ into the graph of $g(x) = \log_{0.1} x$.