Show all steps using algebra, and give all answers in exact form. To the right of each problem written in parentheses is the section number from which the problem originated.

Perform the indicated operations, and simplify.

1. \[
\frac{x^2 - 4}{2x^2 - 2x - 4} \cdot \frac{x^2 - x - 6}{2x^2 - 5x - 3}
\] (7.2)

2. \[
\frac{x - 1}{3x^2 - 5x - 2} - \frac{x}{2x^2 - x - 6}
\] (7.4)

3. \[
\frac{x^2 - 9}{x^2 + 2x} + \frac{x^2 + 4x + 3}{x^2 + x - 2}
\] (7.2)

Evaluate without using a calculator.

4. \[7\sqrt{64}\] (10.1)

5. \[\sqrt[3]{-27}\] (10.1)

6. \[\log_2 \left( \frac{1}{16} \right)\] (12.4)

7. \[e^{\ln 32}\] (12.6)

8. Convert the given logarithmic expression to an equivalent exponential expression:

\[\log_3 \frac{1}{81} = -4\] (12.4)

9. Write as a single logarithm:

\[3\log_2 (x - 1) + \log_2 x - 2\log_2 y\] (12.5)
10. Determine the domain and range of the relation represented by the graph. Write the answers in interval notation. (8.4)

11. Simplify: \( \frac{2 + \frac{1}{x}}{3 - \frac{1}{x^2}} \) (7.7)

12. Find the numbers for which the given expression is undefined:
\[
\frac{x^2 - 25}{x^2 - 2x - 3}
\] (7.1)

13. Solve the given equations algebraically. Show all supporting work and give all answers in exact form.
13. \( 2 + \frac{9}{x^2} = \frac{9}{x} \) (7.5)
14. \( |4x - 2| + 5 = 13 \) (App. E)
15. \( \frac{-3}{x - 4} - \frac{4}{x + 2} = \frac{3}{x^2 - 2x - 8} \) (7.5)
16. \( \sqrt{4 - x} = x - 2 \) (10.6)
17. \( \sqrt{4x + 1} = 6 \) (10.6)
18. \( \sqrt[3]{x + 1} = 2 \) (10.6)
19. \( \sqrt[3]{6x - 3} - 3 = 0 \) (10.6)
20. \( \sqrt{2x - 1} - 4 = -\sqrt{x - 4} \) \hspace{1cm} (10.6)

21. \( (x + 1)^2 - 12 = 0 \) \hspace{1cm} (10.6)

22. \( (3x - 2)^2 + 4 = 0 \) \hspace{1cm} (11.1 or 11.2)

23. \( 2x^2 - 4x = 3 \) \hspace{1cm} (11.1 or 11.2)

24. \( 5x^2 - 3 = 14x \) \hspace{1cm} (11.1 or 11.2)

25. \( x^3 - 5x^3 = -6 \) \hspace{1cm} (11.3)

26. \( x^4 - 3x^2 = 4 \) \hspace{1cm} (11.3)

27. \( 5^{2x-3} = 25 \) \hspace{1cm} (12.3)

28. \( 25^{2x-3} = 5 \) \hspace{1cm} (12.3)

29. \( \log_2(x + 1) = 4 \) \hspace{1cm} (12.4)

30. \( \log_2 x + \log_2(x + 2) = 3 \) \hspace{1cm} (12.7)

31. Given \( \log_b 5 = .8 \) and \( \log_b 3 = .5 \), find \( \log_b 15 \). \hspace{1cm} (12.5)

32. Given the graph of \( f \), graph \( f^{-1} \) on the same set of axes. Label at least three points on the graph of \( f^{-1} \). \hspace{1cm} (12.2)

Simplify each of the following. Use absolute values where appropriate.

33. \( \sqrt{(3x - 8)^2} \) \hspace{1cm} (10.1)

34. \( 5\sqrt{(3x - 8)^5} \) \hspace{1cm} (10.1)
Convert each radical to a rational exponent and simplify. Write the final answer in radical form. Assume all variables represent positive numbers.

35. $\sqrt[3]{x^2} \cdot \sqrt{x}$ (10.2)

36. $\frac{\sqrt[3]{x}}{\sqrt[3]{x^2}}$ (10.2)

Simplify the given radicals. Assume all variables represent positive numbers.

37. $\sqrt[5]{50x^3y^4}$ (10.3)

38. $\sqrt[3]{16x^4y^5}$ (10.3)

Perform the indicated operations and simplify. Assume all variables represent positive numbers.

39. $\sqrt{12xy} \cdot \sqrt[3]{3y}$ (10.4)

40. $\sqrt[3]{8x^3y^4} \cdot \sqrt[4]{4x^3y^3}$ (10.4)

41. $\sqrt{28x} + \sqrt{63x}$ (10.4)

42. $\left(5 - \sqrt[3]{3}\right)\left(6 + \sqrt[2]{2}\right)$ (10.4)

Problems #43-45: Rationalize each denominator. Assume all variables represent positive numbers.

43. $\frac{5\sqrt{3x}}{\sqrt{y}}$ (10.5)

44. $\frac{2 + \sqrt{x}}{3 - \sqrt{x}}$ (10.5)

45. $\frac{4x}{\sqrt[3]{2x^2y^4}}$ (10.5)

Express each in terms of $i$ and simplify.

46. $\sqrt{-36}$ (10.7)

47. $3\sqrt{-25}$ (10.7)

48. $\sqrt{-9} \cdot \sqrt{-16}$ (10.7)
Perform the indicated operations and simplify. Assume all variables represent positive numbers.

49. \[(3 + i)^2 + (4 - 2i)\] (10.7)

50. \[\frac{12 + i}{2 - 3i}\] (10.7)

Solve the given equations by completing the square.

51. \[x^2 - 4x + 1 = 0\] (11.1)
52. \[2x^2 + 3x - 4 = 0\] (11.1)

53. Graph \(f(x) = x^2\) and \(g(x) = x^2 + 3\) on the same set of axes. Tell the number of units and the direction of the shift of \(f\). Label three points on each graph. Make sure the graphs have the correct shape: that of a parabola. Give the coordinates of the vertex and the equation of the axis of symmetry. (11.5)

54. Graph \(f(x) = x^2\) and \(g(x) = (x - 1)^2\) on the same set of axes. Tell the number of units and the direction of the shift of \(f\). Label three points on each graph. Make sure the graphs have the correct shape: that of a parabola. Give the coordinates of the vertex and the equation of the axis of symmetry. (11.5)

55. Graph \(f(x) = x^2\) and \(g(x) = \frac{1}{2}x^2\) on the same set of axes. Label three points on each graph. Make sure the graphs have the correct shape: that of a parabola. Give the coordinates of the vertex and the equation of the axis of symmetry. (11.5)

Calculate the discriminant. Use the discriminant to determine the number and the types of solutions to the quadratic equation.

56. \[-2x^2 + 9x + 5 = 0\] (11.2)
57. \[5x^2 - 4x = -6\] (11.2)
58. \[-9x^2 = 6x - 1\] (11.2)

Given \(f(x) = 4x^2 - x - 7\), find each of the following.

59. \(f(4)\) (8.2)
60. \(f(-2)\) (8.2)
61. \( f(\sqrt{2}) \) (8.2)

62. Use algebra to find any intercepts of the given quadratic functions, and use either the vertex formula or rewriting-in-standard-form method to find the coordinates of the vertex.
   a. \( f(x) = x^2 + 2x - 8 \)
   b. \( f(x) = 2x^2 - 5x - 3 \) (11.6)
   c. \( f(x) = x^2 + 2x + 2 \)

Given \( f(x) = x^2 - 1 \) and \( g(x) = 2x - 3 \), find each of the following.
63. \( f(-3) \) (8.2)
64. \( (f + g)(0) \) (12.1)
65. \( (fg)(x) \) (12.1)
66. \( f(3) + g(-1) \) (12.1)
67. \( (f \circ g)(2) \) (12.1)
68. \( (f \circ g)(x) \) (12.1)

69. State the Vertical Line Test. What is the Vertical Line Test used for? (8.4)
70. State the Horizontal Line Test. What is the Horizontal Line Test used for? (12.2)

For each graph, determine if the graph represents a function and, if it does represent a function, whether the function is a one-to-one function. (12.2)

71.
72. Given \( f(x) = 5x - 7 \), find the inverse function \( f^{-1}(x) \). (12.2)

73. Given \( f(x) = \frac{5x - 7}{6} \), find the inverse function \( f^{-1}(x) \). (12.2)

74. Use the given graph to answer the questions.
76. What is the y-intercept? Give your answer in ordered pair form.
77. What are the x-intercepts? (Give your answer in ordered pair form).
78. If \( x = 0 \), what is \( y \)?
79. If \( f(x) = 3 \), what is \( x \)?
Graph the given functions. Set up a table of coordinates with at least three points. Find x-intercepts and y-intercepts, and any other important features of the graph. For quadratic functions, find the vertex. For an exponential function, give the equation of the horizontal asymptote. Your graphs must have the correct shape.

80. \( f(x) = x^2 - 4 \) \hspace{1cm} (11.5)

81. \( f(x) = (x - 1)^2 + 2 \) \hspace{1cm} (11.5)

82. \( f(x) = -(x + 2)^2 - 4 \) \hspace{1cm} (11.5)

83. \( f(x) = x^2 + 2x - 8 \) \hspace{1cm} (11.6)

84. \( f(x) = 2x^2 - 5x - 3 \) \hspace{1cm} (11.6)

85. \( f(x) = x^2 + 2x + 2 \) \hspace{1cm} (11.6)

86. \( f(x) = \sqrt{x} \) \hspace{1cm} (10.1)

87. \( f(x) = \sqrt[3]{x} \) \hspace{1cm} (10.1)

88. \( f(x) = 2^x - 1 \) \hspace{1cm} (12.3)

89. \( f(x) = \log_2 x \) \hspace{1cm} (12.4)

90. \( f(x) = \log_3 x \) \hspace{1cm} (12.4)

91. \( f(x) = 2^x \) \hspace{1cm} (12.3)

For this part of the review, give exact answers and then use your calculator to approximate to four decimal places.

Use a calculator to evaluate each of the following to four decimal places.

92. \( \sqrt{9} + 19 + \sqrt{25} \) \hspace{1cm} (10.1)

93. \( e^{1.34} \) \hspace{1cm} (12.3)

94. \( \ln 8.3 \) \hspace{1cm} (12.6)

95. \( \log 16.7 \) \hspace{1cm} (12.6)

96. \( \log_2 5.78 \) \hspace{1cm} (12.6)

Solve each of the following equations. Give an exact answer, and then use a calculator to approximate the answer to four decimal places:
97. $4^x = 7$  \hspace{1cm} (12.7)
98. $4^{2x-1} = 7$  \hspace{1cm} (12.7)

For this part of the review, give exact answers and then use your calculator to approximate to the four decimal places.

99. In still water, a boat averages 30 mph. It takes the boat the same amount of time to travel 16 miles downstream as 14 miles upstream. What is the rate of the water’s current?  \hspace{1cm} (7.6)

100. A car travels 60 miles in the same time that a car traveling 10 miles per hour faster travels 90 miles. What is the rate of each car? \hspace{1cm} (7.6)

101. If a projectile is fired straight upward from the ground with an initial speed of 96 feet per second, then its height $h$ in feet after $t$ seconds is given by the function $h(t) = -16t^2 + 96t$. Find the maximum height of the projectile.  \hspace{1cm} (11.6)

102. A water tank on a farm in Flatonia, Texas, can be filled with a large inlet pipe and a small inlet pipe in 3 hours. The large inlet pipe alone can fill the tank in 2 hours less time than the small inlet pipe alone. Find the time each pipe can fill the tank alone.  \hspace{1cm} (11.3)

103. Roma drove 330 miles from her hometown to Tucson. During her return trip she was able to increase her speed by 11 miles per hour. If her return trip took 1 hour less time, find her original speed and her speed returning home.  \hspace{1cm} (7.6)

104. How long does it take $600$ to double if it is invested at 7% compounded monthly?  \hspace{1cm} (12.7)

(The compound interest formula is: $A = P \left(1 + \frac{r}{n}\right)^{nt}$)
105. A person standing close to the edge on the top of a 160-foot building throws a baseball vertically upward. The quadratic function 

\[ s(t) = -16t^2 + 64t + 160 \]

models the ball’s height above the ground, \( s(t) \), in feet, after \( t \) seconds have elapsed. How many seconds does it take until the ball finally hits the ground? \( \text{(11.6)} \)
Optional Final Exam Review Answers:

1. \[ \frac{(x + 2)^2}{2(x + 1)(2x + 1)} - x^2 - 3 \]
2. \[ \frac{(3x + 1)(2x + 3)(x - 2)}{(x - 3)(x - 1)} \]
3. \[ \frac{x(x + 1)}{x(x + 1)} \]
4. 56
5. -3
6. -4
7. 32
8. \[ 3^{-4} = \frac{1}{81} \]
9. \[ \log_2 \left( \frac{(x - 1)^3 x}{y^2} \right) \]
10. Domain: \([-3, \infty)\]
    Range: \([0, \infty)\)
11. \[ \frac{x^2 + x}{3x^2 - 1} \]
12. Undefined for \(x = 3\) and \(x = -1\)
13. \(x = \frac{3}{2}, 3\)
14. \(x = \frac{5}{2}, -\frac{3}{2}\)
15. \(x = 1\)
16. \(x = 0, 3\)
17. \(x = \frac{35}{4}\)
18. \(x = 7\)
19. \(x = 5\)
20. \(x = 5\) (\(x = 85\) doesn’t check)
21. \(x = -1 \pm 2\sqrt{3}\)
22. \[ x = \frac{2 \pm 2i}{3} \]
23. \[ x = \frac{2 \pm \sqrt{10}}{2} \]
24. \(x = -\frac{1}{5}, 3\)
25. \(x = 27, 8\)
26. \(x = \pm 2, \pm i\)
27. \(x = \frac{5}{2}\) (Equate exponents- do not use a calculator.)
28. \(x = \frac{7}{4}\) (Equate exponents- do not use a calculator.)
29. \(x = 15\) (Write as an exponential equation and then solve-no calculator.)
30. \(x = 2\) (\(x = -4\) doesn’t check)
    (Write as an exponential equation and then solve-no calculator.)
31. \(\log_b 15 = 1.3\)
32. See graph on following pages.
33. \(|3x - 8|\)
34. \(3x - 8\)
35. \(\sqrt[42]{x^{19}}\)
36. \(\sqrt[15]{x^7}\)
37. \(5xy^2 \sqrt{2x}\)
38. \(2xy^3 \sqrt{2xy^2}\)
39. \(6y \sqrt{x}\)
40. \(2xy^3 \sqrt{xy^2}\)
41. $5\sqrt{7}x$
42. $30 - 6\sqrt{3} + 5\sqrt{2} - \sqrt{6}$
43. $\frac{5\sqrt{3}xy}{y}$
44. $\frac{6 + 5\sqrt{x} + x}{9 - x}$
45. $\frac{4x^5\sqrt{16x^3}y}{2xy} = 2\frac{\sqrt{16x^3}y}{y}$
46. $6i$
47. $15i$
48. $-12$
49. $12 + 4i$
50. $\frac{21 + 38i}{13}$
51. $2 \pm \sqrt{3}$
52. $-3 \pm \sqrt{41}$
53. See graphs on following pages.
54. See graphs on following pages.
55. See graphs on following pages.
56. $b^2 - 4ac = 121 > 0$
   two real solutions
57. $b^2 - 4ac = -104 < 0$
   two complex sol'n's that are not real
58. $b^2 - 4ac = 72 > 0$
   two real solutions
59. $f(4) = 53$
60. $f(-2) = 11$
61. $f(\sqrt{2}) = 1 - \sqrt{2}$
62. a. $V(-1, -9); x$-intercepts $(-4, 0)$ and $(2, 0)$;
   $y$-intercept $(0, -8)$
   b. $V\left(\frac{5}{4}, -\frac{49}{8}\right)$
   $x$-intercept $\left(-\frac{1}{2}, 0\right)$ $(3, 0)$
   $y$-intercept $(0, -3)$
   c. $V(-1, 1)$
      $x$-intercept none
      $y$-intercept $(0, 2)$
63. $f(-3) = 8$
64. $(f + g)(0) = -4$
65. $(fg)(x) = 2x^3 - 3x^2 - 2x + 3$
66. $f(3) + g(-1) = 3$
67. $(f \circ g)(2) = 0$
68. $(f \circ g)(x) = 4x^2 - 12x + 8$
69. See 8.4 in text.
70. See 12.2 in text.
71. Passes VLT- is a function
   Passes HLT-has an inverse
72. Fails VLT-is not a function
   and can't have an inverse function.
73. Passes VLT- is a function
   Fails HLT-does not have an inverse function
74. $f^{-1}(x) = \frac{6x + 7}{5}$
75. $f^{-1}(x) = x^3 + 1$
76. $(0, -1)$
77. \((-1,0), \ (1, \ 0)\)
78. \(y = -1\)
79. \(x = -2, \ x = 2\)
80-91. See graphs on following pages.
92. \(10.2915\)
93. \(3.8190\)
94. \(2.1163\)
95. \(1.2227\)
96. \(2.5311\)
97. \(1.4037\)
98. \(1.2018\)
99. current’s speed is 2 mph
100. slower car’s speed is 20 mph, faster car’s speed is 30 mph
101. Max. ht is 144 ft.
102. small pipe: 7.1623 hr; large pipe: 5.1623 hr.
103. 55 mph, 66 mph
104. 9.9310 years
105. 5.7417 sec

32. Graph of \(f\) is in purple, and the graph of \(f^{-1}\) is in red.
53. \( f(x) = x^2 \) and \( g(x) = x^2 + 3 \)

<table>
<thead>
<tr>
<th>( x )</th>
<th>( f(x) = x^2 )</th>
<th>( x )</th>
<th>( g(x) = x^2 + 3 )</th>
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<tr>
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<tr>
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Number of units and direction of shift: \textbf{3 units upward}

Vertex and equation of axis of symmetry: \( V(0,3) \), equation of the axis of symmetry: \( x = 0 \)

(Graph of \( f \) is in \textcolor{purple}{purple}, graph of \( g \), in \textcolor{red}{red})

54. \( f(x) = x^2 \) and \( g(x) = (x - 1)^2 \)

<table>
<thead>
<tr>
<th>( x )</th>
<th>( f(x) = x^2 )</th>
<th>( x )</th>
<th>( g(x) )</th>
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</tr>
<tr>
<td>0</td>
<td>((0)^2 = 0)</td>
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<tr>
<td>1</td>
<td>((1)^2 = 1)</td>
<td>2</td>
<td>1</td>
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</table>

Number of units and direction of shift: \textbf{1 unit to the right}

Vertex and equation of axis of symmetry: \( V(1,0) \), equation of the axis of symmetry: \( x = 1 \)

(Graph of \( f \) is in \textcolor{purple}{purple}, graph of \( g \), in \textcolor{red}{red})
55. \( f(x) = x^2 \) and \( g(x) = \frac{1}{2}x^2 \)

<table>
<thead>
<tr>
<th>( x )</th>
<th>( f(x) = x^2 )</th>
<th>( x )</th>
<th>( g(x) )</th>
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<tbody>
<tr>
<td>(-1)</td>
<td>((-1)^2 = 1)</td>
<td>(-1)</td>
<td>(\frac{1}{2})</td>
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<tr>
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<td>((0)^2 = 0)</td>
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<td>(0)</td>
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<tr>
<td>(1)</td>
<td>((1)^2 = 1)</td>
<td>(1)</td>
<td>(\frac{1}{2})</td>
</tr>
</tbody>
</table>

Vertex and equation of axis of symmetry: \( V(0,0) \), equation of axis of symmetry: \( x = 0 \). (Graph of \( f \) is in purple, graph of \( g \), in red)

80. \( f(x) = x^2 - 4 \)

<table>
<thead>
<tr>
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<th>( f(x) )</th>
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<tbody>
<tr>
<td>(-1)</td>
<td>((-1)^2 - 4 = -3)</td>
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<tr>
<td>(0)</td>
<td>((0)^2 - 4 = -4)</td>
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<tr>
<td>(1)</td>
<td>((1)^2 - 4 = -3)</td>
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</table>

\( V(0,-4) \); Equation of axis of symmetry: \( x = 0 \)
81. \( f(x) = (x - 1)^2 + 2 \)

<table>
<thead>
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<tbody>
<tr>
<td>2</td>
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<tr>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

\( V(1,2); \) Equation of axis of symmetry: \( x = 1 \)

82. \( f(x) = -(x + 2)^2 - 4 \)

\( V(-2,-4), \) opens downward

<table>
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<tr>
<td>-2</td>
<td>-4</td>
</tr>
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<td>-5</td>
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</table>

Equation of axis of symmetry: \( x = -2. \)
83. \( f(x) = x^2 + 2x - 8 \)

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<tr>
<td>-1</td>
<td>-9</td>
</tr>
<tr>
<td>0</td>
<td>-8</td>
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</tbody>
</table>

\( V(-1,-9) \); Equation of axis of symmetry: \( x = -1 \).

84. \( f(x) = 2x^2 - 5x - 3 \)

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<tbody>
<tr>
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<td>0</td>
</tr>
<tr>
<td>( \frac{5}{4} )</td>
<td>(- \frac{49}{8} = -6.125 )</td>
</tr>
<tr>
<td>0</td>
<td>-3</td>
</tr>
</tbody>
</table>

\( V\left(\frac{5}{4}, -\frac{49}{8}\right) \); Equation of axis of symmetry: \( x = \frac{5}{4} \).
85. \( f(x) = x^2 + 2x + 2 \)

<table>
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<tr>
<td>-1</td>
<td>1</td>
</tr>
<tr>
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</tbody>
</table>

\( V(-1,1); \text{ Equation of axis of symmetry: } x = -1. \)

86. \( f(x) = 2^x - 1 \) exponential graph, start with \( y = 2^x \) and shift one unit down, horizontal asymptote moves down one unit also to the horizontal line \( y = -1 \).

<table>
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</table>

\( y \)
87. \( f(x) = \log_2 x \) logarithmic graph, domain is \((0, \infty)\)

<table>
<thead>
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<th>y</th>
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</tr>
<tr>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

88. \( f(x) = \log_{1/3} x \) logarithmic graph, domain is \((0, \infty)\)

<table>
<thead>
<tr>
<th>x</th>
<th>y</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>-1</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>1/3</td>
<td>1</td>
</tr>
</tbody>
</table>
89. $f(x) = 2^x$ graph of exponential function, horizontal asymptote is the x-axis (equation of the x-axis is $y = 0$).

<table>
<thead>
<tr>
<th>x</th>
<th>y</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1</td>
<td>0.5</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>