For Thought

1. False, since $\{(1,2),(1,3)\}$ is not a function.

2. False, since $f(5)$ is not defined. **3.** True

4. False, since a student's exam grade is a function of the student's preparation. If two classmates had the same IQ and only one prepared then the one who prepared will most likely achieve a higher grade.

5. False, since $(x+h)^2 = x^2 + 2xh + h^2$

6. False, since the domain is all real numbers.

7. True **8.** True **9.** True

10. False, since $\left(\frac{3}{8}, 8\right)$ and $\left(\frac{3}{8}, 5\right)$ are two ordered pairs with the same first coordinate and different second coordinates.

2.1 Exercises

1. Note, $b = 2\pi a$ is equivalent to $a = \frac{b}{2\pi}$.

Thus, a is a function of b, and b is a function of a.

2. Note, $b = 2(5+a)$ is equivalent to $a = \frac{b-10}{2}$.

So a is a function of b, and b is a function of a.

3. a is a function of b since a given denomination has a unique length. Since a dollar bill and a five-dollar bill have the same length, then b is not a function of a.

4. Since different U.S. coins have different diameters, then a is a function of b and b is a function of a.

5. Since an item has only one price, b is a function of a. Since two items may have the same price, a is not a function of b.

6. a is not a function of b since there may be two students with the same semester grades but different final exams scores. b is not a function of a since there may be identical final exam scores with different semester grades.

7. a is not a function of b since it is possible that two different students can obtain the same final exam score but the times spent on studying are different.

b is not a function of a since it is possible that two different students can spend the same time studying but obtain different final exam scores.

8. a is not a function of b since it is possible that two adult males can have the same shoe size but have different ages.

b is not a function of a since it is possible for two adults with the same age to have different shoe sizes.

9. Since 1 in $\approx$ 2.54 cm, a is a function of b and b is a function of a.

10. Since there is only one cost for mailing a first class letter, then a is a function of b. Since two letters with different weights each under 1/2-ounce cost 34 cents to mail first class, b is not a function of a.

11. No **12.** No **13.** Yes

14. Yes **15.** Yes **16.** No

17. Yes **18.** Yes

19. Not a function since 25 has two different second coordinates. **20.** Yes

21. Not a function since 3 has two different second coordinates.

22. Yes **23.** Yes **24.** Yes

25. Since the ordered pairs in the graph of $y = 3x - 8$ are $(x, 3x-8)$, there are no two ordered pairs with the same first coordinate and different second coordinates. We have a function.

26. Since the ordered pairs in the graph of $y = x^2 - 3x + 7$ are $(x, x^2 - 3x + 7)$, there are no two ordered pairs with the same first coordinate and different second coordinates. We have a function.

27. Since $y = (x+9)/3$, the ordered pairs are $(x,(x+9)/3)$. Thus, there are no two ordered pairs with the same first coordinate and different second coordinates. We have a function.

28. Since $y = \sqrt[3]{x}$, the ordered pairs are $(x, \sqrt[3]{x})$. Thus, there are no two ordered pairs with the same first coordinate and different second coordinates. We have a function.

29. Since $y = \pm x$, the ordered pairs are $(x, \pm x)$. Thus, there are two ordered pairs with the same first coordinate and different second coordinates. We do not have a function.

30. Since $y = \pm\sqrt{9+x^2}$, the ordered pairs are $(x, \pm\sqrt{9+x^2})$. Thus, there are two ordered pairs with the same first coordinate and different second coordinates. We do not have a function.

31. Since $y = x^2$, the ordered pairs are (x, x^2). Thus, there are no two ordered pairs with the same first coordinate and different second coordinates. We have a function.

32. Since $y = x^3$, the ordered pairs are (x, x^3). Thus, there are no two ordered pairs with the same first coordinate and different second coordinates. We have a function.

33. Since $y = |x| - 2$, the ordered pairs are $(x, |x| - 2)$. Thus, there are no two ordered pairs with the same first coordinate and different second coordinates. We have a function.

34. Since $y = 1 + x^2$, the ordered pairs are $(x, 1 + x^2)$. Thus, there are no two ordered pairs with the same first coordinate and different second coordinates. We have a function.

35. Since $(2,1)$ and $(2,-1)$ are two ordered pairs with the same first coordinate and different second coordinates, the equation does not define a function.

36. Since $(2,1)$ and $(2,-1)$ are two ordered pairs with the same first coordinate and different second coordinates, the equation does not define a function.

37. Domain $\{-3,4,5\}$, range $\{1,2,6\}$

38. Domain $\{1,2,3,4\}$, range $\{2,4,8,16\}$

39. Domain $(-\infty,\infty)$, range $\{4\}$

40. Domain $\{5\}$, range $(-\infty,\infty)$

41. Domain $(-\infty,\infty)$;
since $|x| \geq 0$, the range of $y = |x| + 5$ is $[5,\infty)$

42. Domain $(-\infty,\infty)$;
since $x^2 \geq 0$, the range of $y = x^2 + 8$ is $[8,\infty)$

43. Since $x = |y| - 3 \geq -3$, the domain of $x = |y| - 3$ is $[-3,\infty)$; range $(-\infty,\infty)$

44. Since $\sqrt{y} - 2 \geq -2$, the domain of $x = \sqrt{y} - 2$ is $[-2,\infty)$; Since $\sqrt{y}$ is a real number whenever $y \geq 0$, the range is $[0,\infty)$.

45. Since $\sqrt{x-4}$ is a real number whenever $x \geq 4$, the domain of $y = \sqrt{x-4}$ is $[4,\infty)$.

Since $y = \sqrt{x-4} \geq 0$ for $x \geq 4$, the range is $[0,\infty)$.

46. Since $\sqrt{5-x}$ is a real number whenever $x \leq 5$, the domain of $y = \sqrt{5-x}$ is $(-\infty,5]$.

Since $y = \sqrt{5-x} \geq 0$ for $x \leq 5$, the range is $[0,\infty)$.

47. Since $x = -y^2 \leq 0$, the domain of $x = -y^2$ is $(-\infty,0]$; range is $(-\infty,\infty)$;

48. Since $x = -|y| \leq 0$, the domain of $x = -|y|$ is $(-\infty,0]$; range is $(-\infty,\infty)$;

49. 6 **50.** 5

51. $g(2) = 3(2) + 5 = 11$

52. $g(4) = 3(4) + 5 = 17$

53. Since $(3,8)$ is the ordered pair, one obtains $f(3) = 8$. The answer is $x = 3$.

54. Since $(2,6)$ is the ordered pair, one obtains $f(2) = 6$. The answer is $x = 2$.

55. Solving $3x + 5 = 26$, we find $x = 7$.

56. Solving $3x + 5 = -4$, we find $x = -3$.

57. $f(4) + g(4) = 5 + 17 = 22$

58. $f(3) - g(3) = 8 - 14 = -6$

59. $3a^2 - a$ **60.** $3w^2 - w$

61. $4(a+2)-2 = 4a+6$ **62.** $4(a-5)-2 = 4a-22$

63. $3(x^2 + 2x + 1) - (x + 1) = 3x^2 + 5x + 2$

64. $3(x^2 - 6x + 9) - (x - 3) = 3x^2 - 19x + 30$

65. $4(x + h) - 2 = 4x + 4h - 2$

66. $3(x^2+2xh+h^2)-x-h = 3x^2+6xh+3h^2-x-h$

67. $\left[3(x + 1)^2 - (x + 1)\right] - \left[3x^2 - x\right] =$
$\left[3(x^2 + 2x + 1) - (x + 1)\right] - \left[3x^2 - x\right] =$
$6x + 2$

68. $[4(x + 2) - 2] - [4x - 2] = 8$

69. $\left[3(x^2 + 2xh + h^2) - (x + h)\right] - \left[3x^2 - x\right] =$
$3h^2 + 6xh - h$

70. $(4x + 4h - 2) - 4x + 2 = 4h$

71. The average rate of change is

$$\frac{4,000 - 16,000}{5} = -\$2,400 \text{ per year.}$$

72. The average rate of change as the number of cubic yards changes from 12 to 30 and from 30 to 60 are
$\dfrac{528 - 240}{30 - 12} = \$16$ per yd^3 and
$\dfrac{948 - 528}{60 - 30} = \$14$ per yd^3, respectively.

73. The average rate of change on $[0, 2]$ is
$\dfrac{h(2) - h(0)}{2 - 0} = \dfrac{0 - 64}{2 - 0} = -32$ ft/sec.
The average rate of change on $[1, 2]$ is
$\dfrac{h(2) - h(1)}{2 - 1} = \dfrac{0 - 48}{2 - 1} = -48$ ft/sec.
The average rate of change on $[1.9, 2]$ is
$\dfrac{h(2) - h(1.9)}{2 - 1.9} = \dfrac{0 - 6.24}{0.1} = -62.4$ ft/sec.
The average rate of change on $[1.99, 2]$ is
$\dfrac{h(2) - h(1.99)}{2 - 1.99} = \dfrac{0 - 0.6384}{0.01} = -63.84$ ft/sec.
The average rate of change on $[1.999, 2]$ is
$\dfrac{h(2) - h(1.999)}{2 - 1.999} = \dfrac{0 - 0.063984}{0.001} = -63.984$
ft/sec.

74. $\dfrac{6 - 70}{2 - 0} = \dfrac{-64}{2} = -32$ ft/sec

75. The average rate of change is $\dfrac{896 - 1056}{2004 - 1988} =$
-10 million hectares per year.

76. If 10 million hectares are lost each year and since $\dfrac{896}{10} \approx 90$ years, then the forest will be eliminated in the year 2094 ($= 2004 + 90$).

77.

$$\begin{aligned} \frac{f(x+h) - f(x)}{h} &= \frac{4(x+h) - 4x}{h} \\ &= \frac{4h}{h} \\ &= 4 \end{aligned}$$

78.

$$\begin{aligned} \frac{f(x+h) - f(x)}{h} &= \frac{\frac{1}{2}(x+h) - \frac{1}{2}x}{h} \\ &= \frac{\frac{1}{2}h}{h} \\ &= \frac{1}{2} \end{aligned}$$

79.

$$\begin{aligned} \frac{f(x+h) - f(x)}{h} &= \frac{3(x+h) + 5 - 3x - 5}{h} \\ &= \frac{3h}{h} \\ &= 3 \end{aligned}$$

80.

$$\begin{aligned} \frac{f(x+h) - f(x)}{h} &= \frac{-2(x+h) + 3 + 2x - 3}{h} \\ &= \frac{-2h}{h} \\ &= -2 \end{aligned}$$

81. Let $g(x) = x^2 + x$. Then we obtain

$$\begin{aligned} \frac{g(x+h) - g(x)}{h} &= \\ \frac{(x+h)^2 + (x+h) - x^2 - x}{h} &= \\ \frac{2xh + h^2 + h}{h} &= \\ 2x + h + 1. & \end{aligned}$$

82. Let $g(x) = x^2 - 2x$. Then we get

$$\begin{aligned} \frac{g(x+h)-g(x)}{h} &= \\ \frac{(x+h)^2 - 2(x+h) - x^2 + 2x}{h} &= \\ \frac{2xh + h^2 - 2h}{h} &= \\ 2x + h - 2. \end{aligned}$$

83. Difference quotient is

$$\begin{aligned} &= \frac{-(x+h)^2 + (x+h) - 2 + x^2 - x + 2}{h} \\ &= \frac{-2xh - h^2 + h}{h} \\ &= -2x - h + 1 \end{aligned}$$

84. Difference quotient is

$$\begin{aligned} &= \frac{(x+h)^2 - (x+h) + 3 - x^2 + x - 3}{h} \\ &= \frac{2xh + h^2 - h}{h} \\ &= 2x + h - 1 \end{aligned}$$

85. The difference quotient is

$$\begin{aligned} &= \frac{3\sqrt{x+h} - 3\sqrt{x}}{h} \cdot \frac{3\sqrt{x+h} + 3\sqrt{x}}{3\sqrt{x+h} + 3\sqrt{x}} \\ &= \frac{9(x+h) - 9x}{h(3\sqrt{x+h} + 3\sqrt{x})} \\ &= \frac{9h}{h(3\sqrt{x+h} + 3\sqrt{x})} \\ &= \frac{3}{\sqrt{x+h} + \sqrt{x}} \end{aligned}$$

86. Difference quotient is

$$\begin{aligned} &= \frac{-2\sqrt{x+h} + 2\sqrt{x}}{h} \cdot \frac{-2\sqrt{x+h} - 2\sqrt{x}}{-2\sqrt{x+h} - 2\sqrt{x}} \\ &= \frac{4(x+h) - 4x}{h(-2\sqrt{x+h} - 2\sqrt{x})} \\ &= \frac{4h}{h(-2\sqrt{x+h} - 2\sqrt{x})} \\ &= \frac{-2}{\sqrt{x+h} + \sqrt{x}} \end{aligned}$$

87. The difference quotient is

$$\begin{aligned} &= \frac{\sqrt{x+h+2} - \sqrt{x+2}}{h} \cdot \frac{\sqrt{x+h+2} + \sqrt{x+2}}{\sqrt{x+h+2} + \sqrt{x+2}} \\ &= \frac{(x+h+2) - (x+2)}{h(\sqrt{x+h+2} + \sqrt{x+2})} \\ &= \frac{h}{h(\sqrt{x+h+2} + \sqrt{x+2})} \\ &= \frac{1}{\sqrt{x+h+2} + \sqrt{x+2}} \end{aligned}$$

88. Difference quotient is

$$\begin{aligned} &= \frac{\sqrt{\frac{x+h}{2}} - \sqrt{\frac{x}{2}}}{h} \cdot \frac{\sqrt{\frac{x+h}{2}} + \sqrt{\frac{x}{2}}}{\sqrt{\frac{x+h}{2}} + \sqrt{\frac{x}{2}}} \\ &= \frac{\frac{x+h}{2} - \frac{x}{2}}{h\left(\sqrt{\frac{x+h}{2}} + \sqrt{\frac{x}{2}}\right)} \\ &= \frac{\frac{h}{2}}{h\left(\sqrt{\frac{x+h}{2}} + \sqrt{\frac{x}{2}}\right)} \\ &= \frac{1}{2\left(\sqrt{\frac{x+h}{2}} + \sqrt{\frac{x}{2}}\right)} \\ &= \frac{1}{\sqrt{2}\left(\sqrt{x+h} + \sqrt{x}\right)} \end{aligned}$$

89. Difference quotient is

$$\begin{aligned} &= \frac{\frac{1}{x+h} - \frac{1}{x}}{h} \cdot \frac{x(x+h)}{x(x+h)} \\ &= \frac{x - (x+h)}{xh(x+h)} \\ &= \frac{-h}{xh(x+h)} \\ &= \frac{-1}{x(x+h)} \end{aligned}$$

90. Difference quotient is

$$= \frac{\dfrac{3}{x+h} - \dfrac{3}{x}}{h} \cdot \frac{x(x+h)}{x(x+h)}$$
$$= \frac{3x - 3(x+h)}{xh(x+h)}$$
$$= \frac{-3h}{xh(x+h)}$$
$$= \frac{-3}{x(x+h)}$$

91. Difference quotient is

$$= \frac{\dfrac{3}{x+h+2} - \dfrac{3}{x+2}}{h} \cdot \frac{(x+h+2)(x+2)}{(x+h+2)(x+2)}$$
$$= \frac{3(x+2) - 3(x+h+2)}{h(x+h+2)(x+2)}$$
$$= \frac{-3h}{h(x+h+2)(x+2)}$$
$$= \frac{-3}{(x+h+2)(x+2)}$$

92. Difference quotient is

$$= \frac{\dfrac{2}{x+h-1} - \dfrac{2}{x-1}}{h} \cdot \frac{(x+h-1)(x-1)}{(x+h-1)(x-1)}$$
$$= \frac{2(x-1) - 2(x+h-1)}{h(x+h-1)(x-1)}$$
$$= \frac{-2h}{h(x+h-1)(x-1)}$$
$$= \frac{-2}{(x+h-1)(x-1)}$$

93. **a)** $A = s^2$ **b)** $s = \sqrt{A}$ **c)** $s = \dfrac{d\sqrt{2}}{2}$
d) $d = s\sqrt{2}$ **e)** $P = 4s$ **f)** $s = P/4$
g) $A = P^2/16$ **h)** $d = \sqrt{2A}$

94. **a)** $A = \pi r^2$ **b)** $r = \sqrt{\dfrac{A}{\pi}}$ **c)** $C = 2\pi r$
d) $d = 2r$ **e)** $d = \dfrac{C}{\pi}$ **f)** $A = \dfrac{\pi d^2}{4}$
g) $d = 2\sqrt{\dfrac{A}{\pi}}$

95. $C = 50 + 35n$

96. **a)** When $d = 100$ ft, the atmospheric pressure is $A(100) = .03(100) + 1 = 4$ atm.
b) When $A = 4.9$ atm, the depth is found by solving $4.9 = 0.03d + 1$; the depth is

$$d = \frac{3.9}{0.03} = 130 \text{ ft}.$$

97.

(a) The quantity $C(4) = (0.95)(4) + 5.8 =$ \$9.6 billion represents the amount spent on computers in the year 2004.

(b) By solving $0.95n + 5.8 = 15$, we obtain

$$n = \frac{9.2}{0.95} \approx 10.$$

Thus, spending for computers will be \$15 billion in 2010.

98.

(a) The quantity $E(4) + C(4) = [0.5(4) + 1] + 9.6 =$ \$12.6 billion represents the total amount spent on electronics and computers in the year 2004.

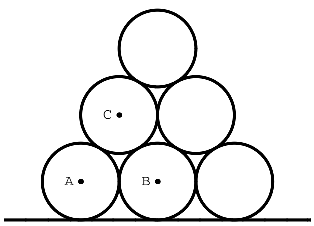
(b) By solving

$$\begin{aligned} (0.5n + 1) + (0.95n + 5.8) &= 20 \\ 1.45n &= 13.2 \\ n &\approx 9 \end{aligned}$$

we find that the total spending will reach \$20 billion in the year 2009 $(= 2000 + 9)$.

(c) The amount spent on computers is growing faster since the slope of $C(n)$ [which is 1] is greater than the slope of $E(n)$ [which is 0.95].

99. Let a be the radius of each circle. Note, triangle $\triangle ABC$ is an equilateral triangle with side $2a$ and height $\sqrt{3}a$.

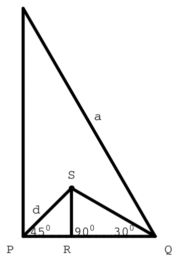


Thus, the height of the circle centered at C from the horizontal line is $\sqrt{3}a + 2a$. Hence, by using a similar reasoning, we obtain that height of the highest circle from the line is

$$2\sqrt{3}a + 2a$$

or equivalently $(2\sqrt{3} + 2)a$.

100. In the triangle below, PS bisects the 90-angle at P and SQ bisects the 60-angle at Q.



In the 45-45-90 triangle $\triangle SPR$, we find

$$PR = SR = \sqrt{2}d/2.$$

And, in the 30-60-90 triangle $\triangle SQR$ we get

$$PQ = \frac{\sqrt{6}}{2}d.$$

Since $PQ = PR + RQ$, we obtain

$$\begin{aligned} \frac{a}{2} &= \frac{\sqrt{2}}{2}d + \frac{\sqrt{6}}{2}d \\ a &= \sqrt{2}d + \sqrt{6}d \\ a &= (\sqrt{6} + \sqrt{2})d \\ d &= \frac{a}{\sqrt{6} + \sqrt{2}} \\ d &= \frac{\sqrt{6} - \sqrt{2}}{4}a. \end{aligned}$$

101. When $x = 18$ and $h = 0.1$, we have

$$\frac{R(18.1) - R(18)}{0.1} = 1,950.$$

The revenue from the concert will increase by approximately \$1,950 if the price of a ticket is raised from \$18 to \$19.

If $x = 22$ and $h = 0.1$, then

$$\frac{R(22.1) - R(22)}{0.1} = -2,050.$$

The revenue from the concert will decrease by approximately \$2,050 if the price of a ticket is raised from \$22 to \$23.

102. When $r = 1.4$ and $h = 0.1$, we obtain

$$\frac{A(1.5) - A(1.4)}{0.1} \approx -16.1$$

The amount of tin needed decreases by approximately 16.1 in.^{2} if the radius increases from 1.4 in. to 2.4 in.

If $r = 2$ and $h = 0.1$, then

$$\frac{A(2.1) - A(2)}{0.1} \approx 8.6$$

The amount of tin needed increases by about 8.6 in.^{2} if the radius increases from 2 in. to 3 in.

Thinking Outside the Box XX

$(30 + 25)^2 = 3025$

2.1 Pop Quiz

1. Yes, since $A = \pi r^2$ where A is the area of a circle with radius r.

2. No, since the ordered pairs $(2, 4)$ and $(-2, 4)$ have the same first coordinates.

3. No, since the ordered pairs $(1, 0)$ and $(-1, 0)$ have the same first coordinates.

4. $[1, \infty)$ **5.** $[2, \infty)$ **6.** 9

7. If $2a = 1$, then $a = 1/2$.

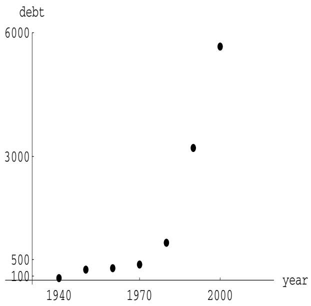
8. $\dfrac{40 - 20}{2008 - 1998} = \$2$ per year

9. The difference quotient is

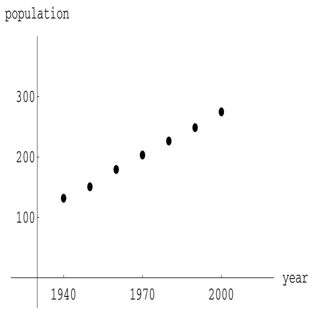
$$\begin{aligned} \frac{f(x+h) - f(x)}{h} &= \frac{(x+h)^2 + 3 - x^2 - 3}{h} \\ &= \frac{x^2 + 2xh + h^2 - x^2}{h} \\ &= \frac{2xh + h^2}{h} \\ &= 2x + h \end{aligned}$$

2.1 Linking Concepts

(a) The first graph shows U.S. federal debt D versus year y



and the second graph shows population P (in millions) versus y.



(b) The first table shows the average rates of change for the U.S. federal debt

10 – year period	ave. rate of change
1940 – 50	$\frac{257-51}{10} = 20.6$
1950 – 60	$\frac{291-257}{10} = 3.4$
1960 – 70	$\frac{381-291}{10} = 9.0$
1970 – 80	$\frac{909-381}{10} = 52.8$
1980 – 90	$\frac{3207-909}{10} = 229.8$
1990 – 2000	$\frac{5666-3207}{10} = 245.9$

The second table shows the average rates of change for the U.S. population

10 – year period	ave. rate of change
1940 – 50	$\frac{150.7-131.7}{10} \approx 1.9$
1950 – 60	$\frac{179.3-150.7}{10} \approx 2.9$
1960 – 70	$\frac{203.3-179.3}{10} \approx 2.4$
1970 – 80	$\frac{226.5-203.3}{10} \approx 2.3$
1980 – 90	$\frac{248.7-226.5}{10} \approx 2.2$
1990 – 2000	$\frac{274.8-248.7}{10} \approx 2.6$

(c) The first table shows the difference between consecutive average rates of change for the U.S. federal debt.

10-year periods	difference
1940-50 & 1950-60	$3.4 - 20.6 = -17.2$
1950-60 & 1960-70	$9.0 - 3.4 = 5.6$
1960-70 & 1970-80	$52.8 - 9.0 = 43.8$
1970-80 & 1980-90	$229.8 - 52.8 = 177.0$
1980-90 & 1990-00	$245.9 - 229.8 = 16.1$

The second table shows the difference between consecutive average rates of change for the U.S. population.

10-year periods	difference
1940-50 & 1950-60	$2.9 - 1.9 = 1.0$
1950-60 & 1960-70	$2.4 - 2.9 = -0.5$
1960-70 & 1970-80	$2.3 - 2.4 = -0.1$
1970-80 & 1980-90	$2.2 - 2.3 = -0.1$
1980-90 & 1990-00	$2.6 - 2.2 = 0.4$

(d) For both the U.S. federal debt and population, the average rates of change are all positive.

(e) In part (c), for the federal debt most of the differences are positive and for the population most of the differences are negative.

(f) The U.S. federal debt is growing out of control when compared to the U.S. population. See part (g) for an explanation.

(g) Since most of the differences for the federal debt in part (e) are positive, the federal debts are increasing at an increasing rate. While the U.S. population is increasing at a decreasing rate since most of the differences for population in part (e) are negative.

For Thought

1. True, since the graph is a parabola opening down with vertex at the origin.

2. False, the graph is decreasing.

3. True

4. True, since $f(-4.5) = [-1.5] = -2$.

5. False, since the range is $\{\pm 1\}$.

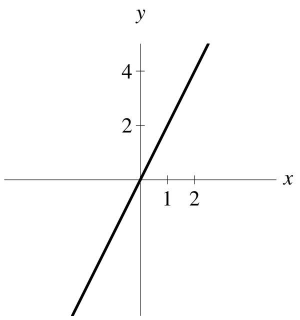
6. True **7.** True **8.** True

9. False, since the range is the interval $[0, 4]$.

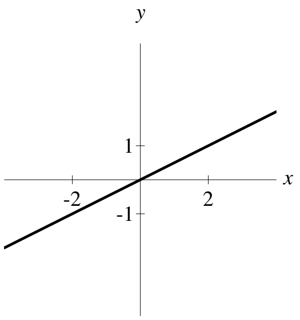
10. True

2.2 Exercises

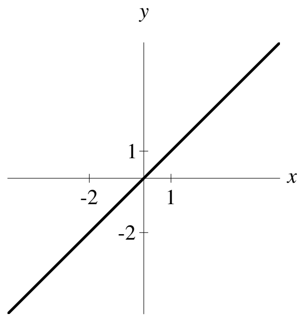
1. Function $y = 2x$ includes the points $(0, 0), (1, 2)$, domain and range are both $(-\infty, \infty)$



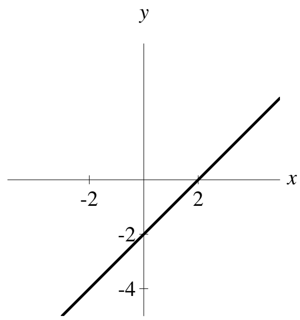
2. Function $x = 2y$ includes the points $(0, 0)$, $(2, 1), (-2, -1)$, domain and range are both $(-\infty, \infty)$



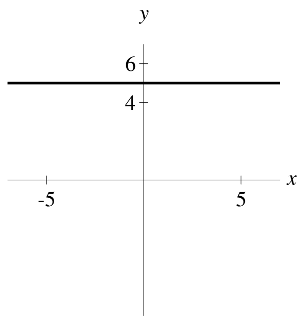
3. Function $x - y = 0$ includes the points $(-1, -1)$, $(0, 0), (1, 1)$, domain and range are both $(-\infty, \infty)$



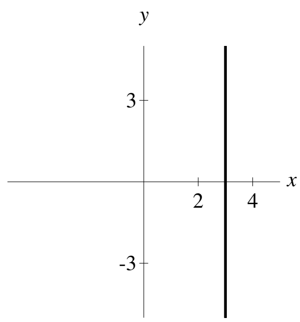
4. Function $x - y = 2$ includes the points $(2, 0)$, $(0, -2), (-2, -4)$, domain and range are both $(-\infty, \infty)$



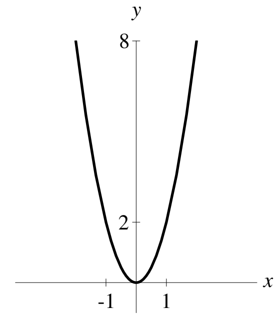
5. Function $y = 5$ includes the points $(0, 5)$, $(\pm 2, 5)$, domain is $(-\infty, \infty)$, range is $\{5\}$



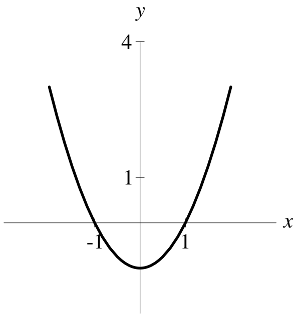
6. $x = 3$ is not a function and includes the points $(3, 0), (3, 2)$, domain is $\{3\}$, range is $(-\infty, \infty)$



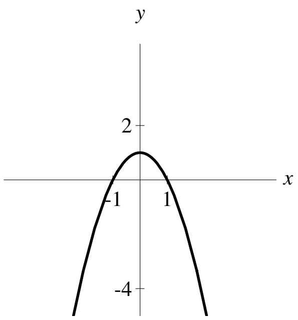
7. Function $y = 2x^2$ includes the points $(0, 0)$, $(\pm 1, 2)$, domain is $(-\infty, \infty)$, range is $[0, \infty)$



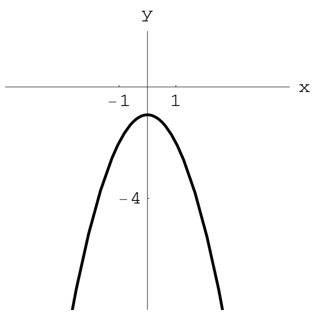
8. Function $y = x^2 - 1$ goes through $(0, -1)$, $(\pm 1, 0)$, domain is $(-\infty, \infty)$, range is $[-1, \infty)$



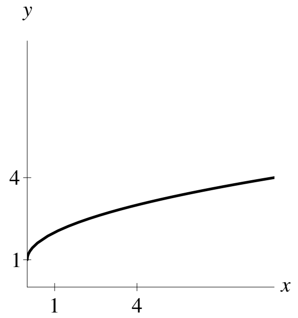
9. Function $y = 1 - x^2$ includes the points $(0, 1)$, $(\pm 1, 0)$, domain is $(-\infty, \infty)$, range is $(-\infty, 1]$



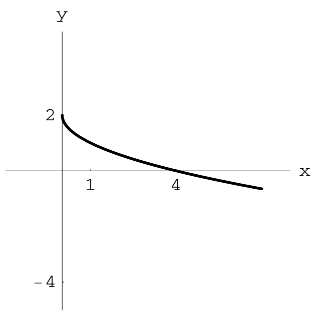
10. Function $y = -1 - x^2$ includes the points $(0, -1)$, $(\pm 1, -2)$, domain is $(-\infty, \infty)$, range is $(-\infty, -1]$



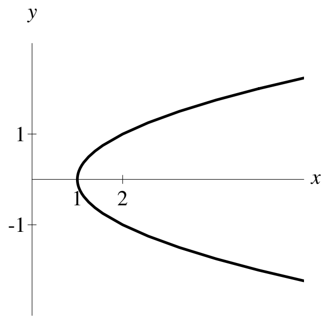
11. Function $y = 1 + \sqrt{x}$ includes the points $(0, 1)$, $(1, 2), (4, 3)$, domain is $[0, \infty)$, range is $[1, \infty)$



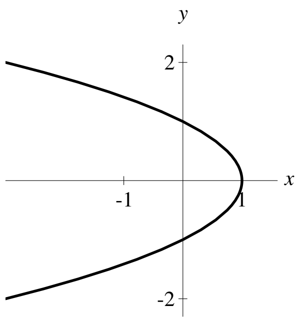
12. Function $y = 2 - \sqrt{x}$ includes the points $(0, 2)$, $(4, 0)$, domain is $[0, \infty)$, range is $(-\infty, 2]$



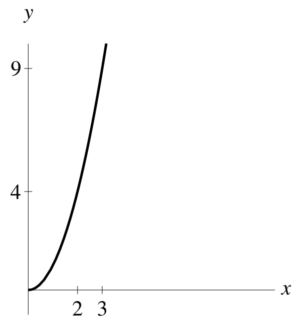
13. $x = y^2 + 1$ is not a function and includes the points $(1, 0), (2, \pm 1)$, domain is $[1, \infty)$, range is $(-\infty, \infty)$



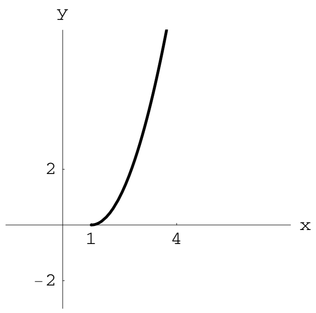
14. $x = 1 - y^2$ is not function and includes the points $(1, 0), (0, \pm 1)$, domain is $(-\infty, 1]$, range is $(-\infty, \infty)$



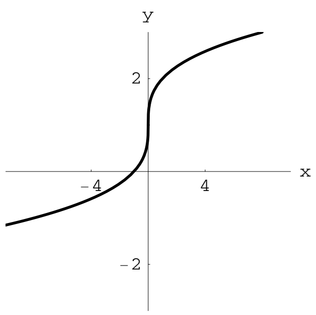
15. Function $x = \sqrt{y}$ goes through $(0,0), (2,4), (3,9)$, domain and range is $[0,\infty)$



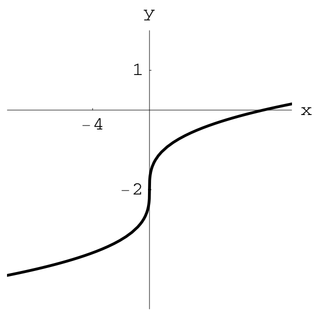
16. Function $x - 1 = \sqrt{y}$ goes through $(1,0)$, $(3,4), (4,9)$, domain $[1,\infty)$, and range $[0,\infty)$,



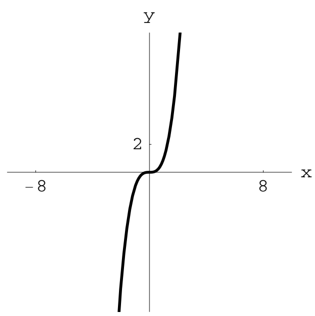
17. Function $y = \sqrt[3]{x} + 1$ goes through $(-1,0), (1,2), (8,3)$, domain $(-\infty,\infty)$, and range $(-\infty,\infty)$



18. Function $y = \sqrt[3]{x} - 2$ goes through $(-1,-3), (1,-1), (8,0)$, domain $(-\infty,\infty)$, and range $(-\infty,\infty)$



19. Function, $x = \sqrt[3]{y}$ goes through $(0,0), (1,1), (2,8)$, domain $(-\infty,\infty)$, and range $(-\infty,\infty)$



20. Function, $x = \sqrt[3]{y-1}$ goes through $(0,1), (1,2), (-1,0)$, domain $(-\infty,\infty)$, and range $(-\infty,\infty)$