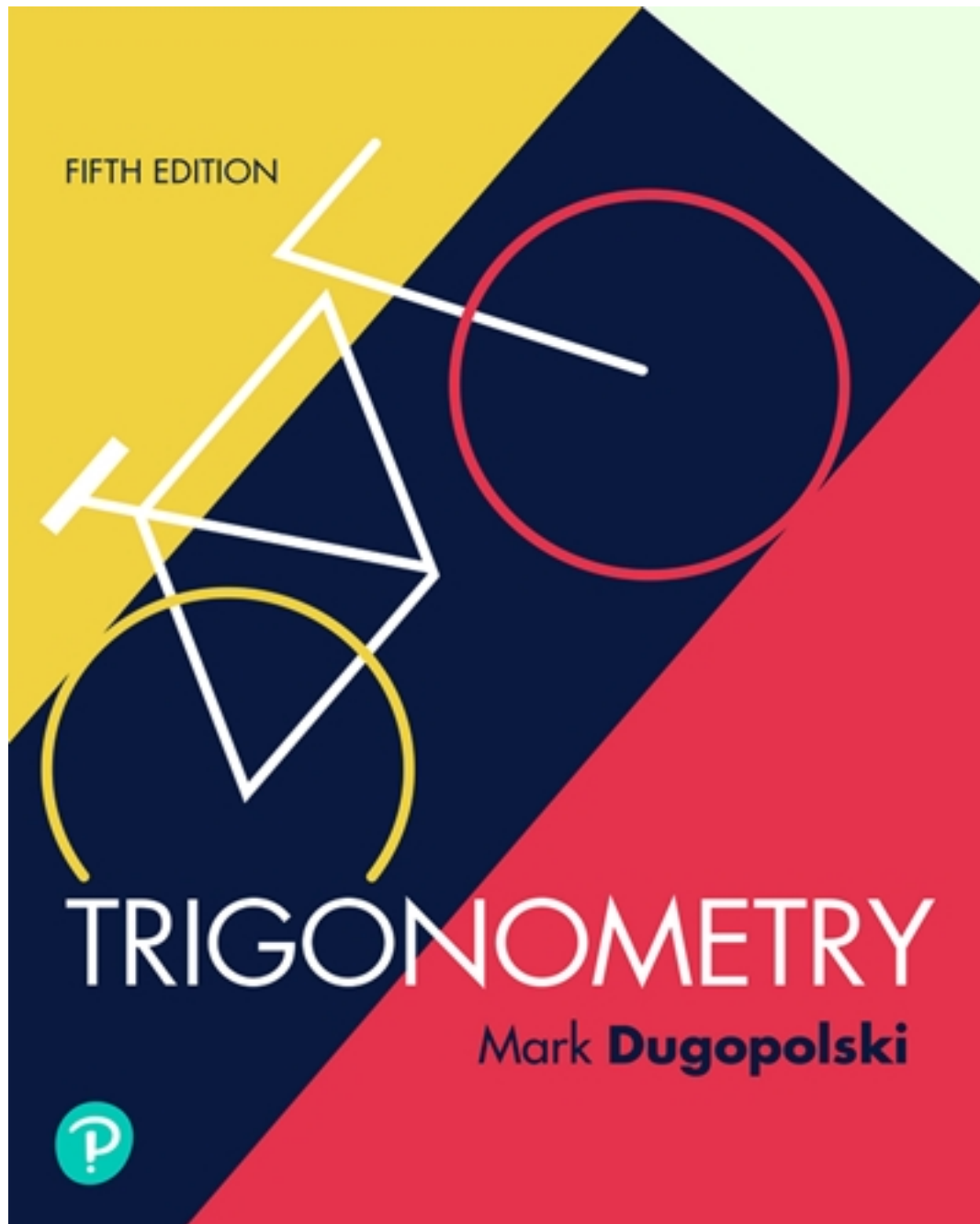


Solutions for Trigonometry 5th Edition by Dugopolski

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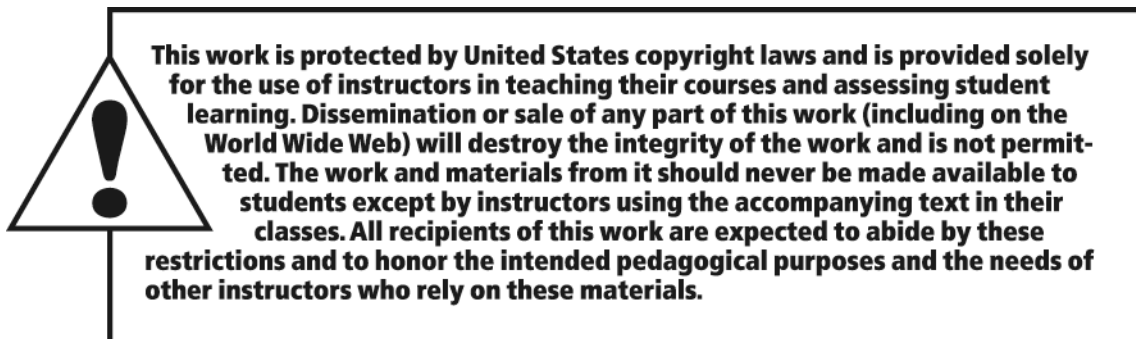
Solutions

INSTRUCTOR'S SOLUTIONS MANUAL

EDGAR REYES
Southeastern Louisiana University

TRIGONOMETRY FIFTH EDITION

Mark Dugopolski
Southeastern Louisiana University



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ISBN-13: 978-0-13-520744-4

ISBN-10: 0-13-520744-4

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For Thought

- False, the point $(2, -3)$ is in Quadrant IV.
- False, the point $(4, 0)$ does not belong to any quadrant.
- False, since the distance is $\sqrt{(a-c)^2 + (b-d)^2}$.
- False, since $Ax + By = C$ is a linear equation.
- True
- False, since $\sqrt{7^2 + 9^2} = \sqrt{130} \approx 11.4$
- True
- True
- True
- False, since the radius is 3.

P.1 Exercises

- ordered
- Cartesian
- x -axis
- origin
- Pythagorean theorem
- circle
- linear equation
- y -intercept
- $(4, 1)$, Quadrant I
- $(-3, 2)$, Quadrant II
- $(1, 0)$, x -axis
- $(-1, -5)$, Quadrant III
- $(5, -1)$, Quadrant IV
- $(0, -3)$, y -axis
- $(-4, -2)$, Quadrant III
- $(-2, 0)$, x -axis
- $(-2, 4)$, Quadrant II
- $(1, 5)$, Quadrant I
- $c = \sqrt{(\sqrt{3})^2 + 1^2} = \sqrt{4} = 2$
- Since $a^2 + a^2 = \sqrt{2}^2$, we get $2a^2 = 2$ or $a^2 = 1$. Then $a = 1$.
- Since $b^2 + 2^2 = 3^2$, we get $b^2 + 4 = 9$ or $b^2 = 5$. Then $b = \sqrt{5}$.
- Since $b^2 + \left(\frac{1}{2}\right)^2 = 1^2$, we get $b^2 + \frac{1}{4} = 1$ or $b^2 = \frac{3}{4}$. Thus, $b = \frac{\sqrt{3}}{2}$.
- Since $a^2 + 3^2 = 5^2$, we get $a^2 + 9 = 25$ or $a^2 = 16$. Then $a = 4$.
- $c = \sqrt{3^2 + 2^2} = \sqrt{9 + 4} = \sqrt{13}$
- $\sqrt{4 \cdot 7} = 2\sqrt{7}$
- $\sqrt{25 \cdot 2} = 5\sqrt{2}$
- $\frac{\sqrt{5}}{\sqrt{9}} = \frac{\sqrt{5}}{3}$
- $\frac{\sqrt{3}}{\sqrt{16}} = \frac{\sqrt{3}}{4}$
- $\frac{\sqrt{2}}{\sqrt{3}} \cdot \frac{\sqrt{3}}{\sqrt{3}} = \frac{\sqrt{6}}{3}$
- $\frac{\sqrt{3}}{\sqrt{5}} \cdot \frac{\sqrt{5}}{\sqrt{5}} = \frac{\sqrt{15}}{5}$
- $\frac{2\sqrt{3}}{\sqrt{5}} \cdot \frac{\sqrt{5}}{\sqrt{5}} = \frac{2\sqrt{15}}{5}$
- $\frac{5}{\sqrt{3}} \cdot \frac{\sqrt{3}}{\sqrt{3}} = \frac{5\sqrt{3}}{3}$
- $\frac{1}{\sqrt{3}} \cdot \frac{\sqrt{3}}{\sqrt{3}} = \frac{\sqrt{3}}{3}$
- $\frac{3}{\sqrt{2}} \cdot \frac{\sqrt{2}}{\sqrt{2}} = \frac{3\sqrt{2}}{2}$
- $\frac{\sqrt{2}}{\sqrt{3}} \cdot \frac{\sqrt{3}}{\sqrt{3}} = \frac{\sqrt{6}}{3}$
- $\frac{\sqrt{5}}{\sqrt{2}} \cdot \frac{\sqrt{2}}{\sqrt{2}} = \frac{\sqrt{10}}{2}$
- Distance is $\sqrt{(4-1)^2 + (7-3)^2} = \sqrt{9+16} = \sqrt{25} = 5$, midpoint is $(2.5, 5)$
- Distance is $\sqrt{144+25} = 13$, midpoint is $(3, 0.5)$
- Distance is $\sqrt{(-1-1)^2 + (-2-0)^2} = \sqrt{4+4} = 2\sqrt{2}$, midpoint is $(0, -1)$

40. Distance is $\sqrt{4+4} = 2\sqrt{2}$, midpoint is $(0, 1)$

41. Distance is $\sqrt{\left(\frac{\sqrt{2}}{2} - 0\right)^2 + \left(\frac{\sqrt{2}}{2} - 0\right)^2} =$
 $\sqrt{\frac{2}{4} + \frac{2}{4}} = \sqrt{1} = 1$, midpoint is
 $\left(\frac{\sqrt{2}/2 + 0}{2}, \frac{\sqrt{2}/2 + 0}{2}\right) = \left(\frac{\sqrt{2}}{4}, \frac{\sqrt{2}}{4}\right)$

42. Distance is $\sqrt{(\sqrt{3} - 0)^2 + (1 - 0)^2} =$
 $\sqrt{3+1} = 2$, midpoint is
 $\left(\frac{\sqrt{3} + 0}{2}, \frac{1 + 0}{2}\right) = \left(\frac{\sqrt{3}}{2}, \frac{1}{2}\right)$

43. Distance is $\sqrt{(\sqrt{18} - \sqrt{8})^2 + (\sqrt{12} - \sqrt{27})^2} =$
 $\sqrt{(3\sqrt{2} - 2\sqrt{2})^2 + (2\sqrt{3} - 3\sqrt{3})^2} =$
 $\sqrt{(\sqrt{2})^2 + (-\sqrt{3})^2} = \sqrt{5}$,
 midpoint is $\left(\frac{\sqrt{18} + \sqrt{8}}{2}, \frac{\sqrt{12} + \sqrt{27}}{2}\right) =$
 $\left(\frac{3\sqrt{2} + 2\sqrt{2}}{2}, \frac{2\sqrt{3} + 3\sqrt{3}}{2}\right) = \left(\frac{5\sqrt{2}}{2}, \frac{5\sqrt{3}}{2}\right)$

44. Distance is $\sqrt{(\sqrt{72} - \sqrt{50})^2 + (\sqrt{45} - \sqrt{20})^2} =$
 $\sqrt{(6\sqrt{2} - 5\sqrt{2})^2 + (3\sqrt{5} - 2\sqrt{5})^2} =$
 $\sqrt{(\sqrt{2})^2 + (\sqrt{5})^2} = \sqrt{7}$,
 midpoint is $\left(\frac{\sqrt{72} + \sqrt{50}}{2}, \frac{\sqrt{45} + \sqrt{20}}{2}\right) =$
 $\left(\frac{6\sqrt{2} + 5\sqrt{2}}{2}, \frac{3\sqrt{5} + 2\sqrt{5}}{2}\right) = \left(\frac{11\sqrt{2}}{2}, \frac{5\sqrt{5}}{2}\right)$

45. Distance is $\sqrt{(1.2 + 3.8)^2 + (4.4 + 2.2)^2} =$
 $\sqrt{25 + 49} = \sqrt{74}$, midpoint is $(-1.3, 1.3)$

46. Distance is $\sqrt{49 + 81} = \sqrt{130}$,
 midpoint is $(1.2, -3)$

47. Distance is $\frac{\sqrt{\pi^2 + 4}}{2}$, midpoint is $\left(\frac{3\pi}{4}, \frac{1}{2}\right)$

48. Distance is $\frac{\sqrt{\pi^2 + 4}}{2}$, midpoint is $\left(\frac{\pi}{4}, \frac{1}{2}\right)$

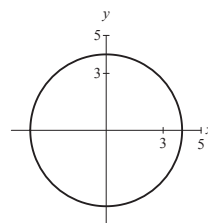
49. Distance is $\sqrt{(2\pi - \pi)^2 + (0 - 0)^2} = \sqrt{\pi^2} = \pi$,
 midpoint is $\left(\frac{2\pi + \pi}{2}, \frac{0 + 0}{2}\right) = \left(\frac{3\pi}{2}, 0\right)$

50. Distance is $\sqrt{\left(\pi - \frac{\pi}{2}\right)^2 + (1 - 1)^2} = \sqrt{\frac{\pi^2}{4}} =$
 $\frac{\pi}{2}$, midpoint is $\left(\frac{\pi + \pi/2}{2}, \frac{1 + 1}{2}\right) = \left(\frac{3\pi}{4}, 1\right)$

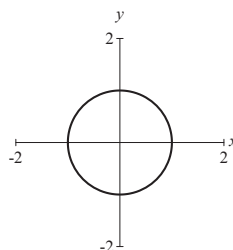
51. Distance is $\sqrt{\left(\frac{\pi}{2} - \frac{\pi}{3}\right)^2 + \left(-\frac{1}{3} - \frac{1}{2}\right)^2} =$
 $\sqrt{\frac{\pi^2}{36} + \frac{25}{36}} = \frac{\sqrt{\pi^2 + 25}}{6}$,
 midpoint is $\left(\frac{\frac{\pi}{2} + \frac{\pi}{3}}{2}, \frac{\frac{1}{2} - \frac{1}{3}}{2}\right) = \left(\frac{5\pi}{12}, \frac{1}{12}\right)$

52. Distance is $\sqrt{\left(\pi - \frac{2\pi}{3}\right)^2 + \left(-1 + \frac{1}{2}\right)^2} =$
 $\sqrt{\frac{\pi^2}{9} + \frac{1}{4}} = \frac{\sqrt{4\pi^2 + 9}}{6}$,
 midpoint is $\left(\frac{\frac{2\pi}{3} + \pi}{2}, \frac{-\frac{1}{2} - 1}{2}\right) = \left(\frac{5\pi}{6}, -\frac{3}{4}\right)$

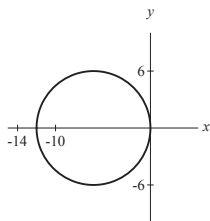
53. Center $(0, 0)$, radius 4



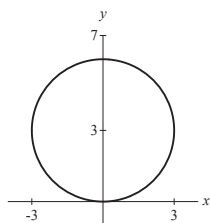
54. Center $(0, 0)$, radius 1



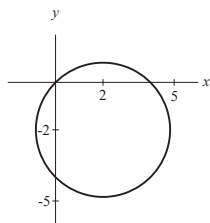
55. Center $(-6, 0)$, radius 6



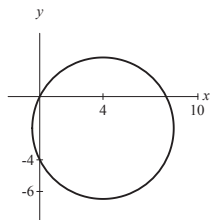
56. Center $(0, 3)$, radius 3



57. Center $(2, -2)$, radius $2\sqrt{2}$



58. Center $(4, -2)$, radius $2\sqrt{5}$



59. $x^2 + y^2 = 7$

60. $x^2 + y^2 = 12$ since $(2\sqrt{3})^2 = 12$

61. $(x + 2)^2 + (y - 5)^2 = 1/4$

62. $(x + 1)^2 + (y + 6)^2 = 1/9$

63. The distance between $(3, 5)$ and the origin is $\sqrt{34}$ which is the radius. The standard equation is $(x - 3)^2 + (y - 5)^2 = 34$.

64. The distance between $(-3, 9)$ and the origin is $\sqrt{90}$ which is the radius. The standard equation is $(x + 3)^2 + (y - 9)^2 = 90$.

65. Note, the distance between $(\sqrt{2}/2, \sqrt{2}/2)$ and the origin is 1. Thus, the radius is 1. The standard equation is $x^2 + y^2 = 1$.

66. Note, the distance between $(\sqrt{3}/2, 1/2)$ and the origin is 1. Thus, the radius is 1. The standard equation is $x^2 + y^2 = 1$.

67. The radius is $\sqrt{(-1 - 0)^2 + (2 - 0)^2} = \sqrt{5}$. The standard equation is $(x + 1)^2 + (y - 2)^2 = 5$.

68. Since the center is $(0, 0)$ and the radius is 2, the standard equation is $x^2 + y^2 = 4$.

69. Note, the center is $(1, 3)$ and the radius is 2. The standard equation is $(x - 1)^2 + (y - 3)^2 = 4$.

70. The radius is $\sqrt{(2 - 0)^2 + (2 - 0)^2} = \sqrt{8}$. The standard equation is $(x - 2)^2 + (y - 2)^2 = 8$.

71. We solve for a .

$$\begin{aligned} a^2 + \left(\frac{3}{5}\right)^2 &= 1 \\ a^2 &= 1 - \frac{9}{25} \\ a^2 &= \frac{16}{25} \\ a &= \pm \frac{4}{5} \end{aligned}$$

72. We solve for a .

$$\begin{aligned} a^2 + \left(-\frac{1}{2}\right)^2 &= 1 \\ a^2 &= 1 - \frac{1}{4} \\ a^2 &= \frac{3}{4} \\ a &= \pm \frac{\sqrt{3}}{2} \end{aligned}$$

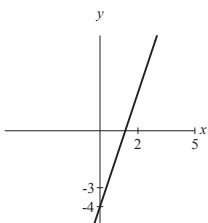
73. We solve for a .

$$\begin{aligned} \left(-\frac{2}{5}\right)^2 + a^2 &= 1 \\ a^2 &= 1 - \frac{4}{25} \\ a^2 &= \frac{21}{25} \\ a &= \pm \frac{\sqrt{21}}{5} \end{aligned}$$

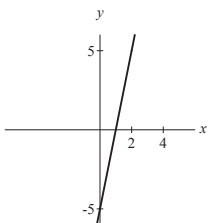
74. Solve for a :

$$\begin{aligned}\left(\frac{2}{3}\right)^2 + a^2 &= 1 \\ a^2 &= 1 - \frac{4}{9} \\ a^2 &= \frac{5}{9} \\ a &= \pm \frac{\sqrt{5}}{3}\end{aligned}$$

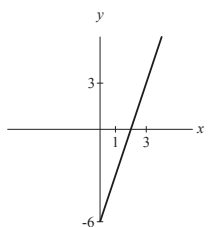
75. $y = 3x - 4$ goes through $(0, -4)$, $\left(\frac{4}{3}, 0\right)$.



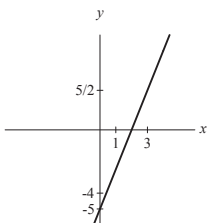
76. $y = 5x - 5$ goes through $(0, -5)$, $(1, 0)$.



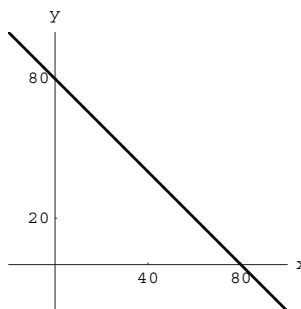
77. $3x - y = 6$ goes through $(0, -6)$, $(2, 0)$.



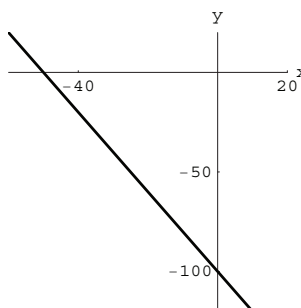
78. $5x - 2y = 10$ goes through $(0, -5)$, $(2, 0)$.



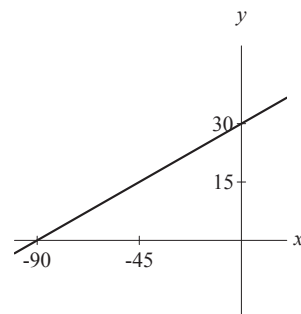
79. $x + y = 80$ goes through $(0, 80)$, $(80, 0)$.



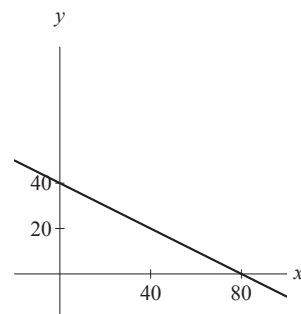
80. $2x + y = -100$ goes through $(0, -100)$, $(-50, 0)$.



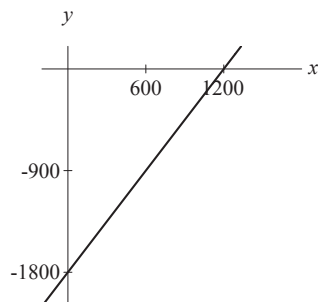
81. $x = 3y - 90$ goes through $(0, 30)$, $(-90, 0)$.



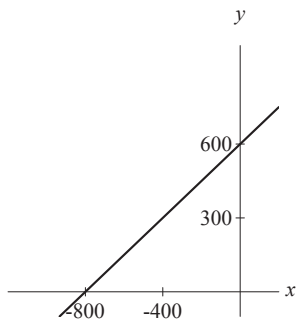
82. $x = 80 - 2y$ goes through $(0, 40)$, $(80, 0)$.



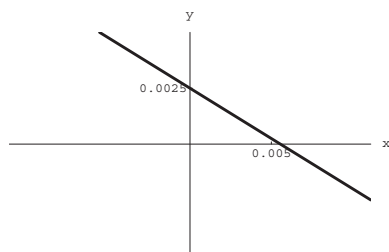
83. $\frac{1}{2}x - \frac{1}{3}y = 600$ goes through $(0, -1800)$, $(1200, 0)$.



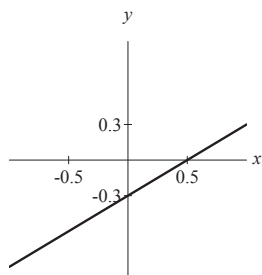
84. $\frac{2}{3}y - \frac{1}{2}x = 400$ goes through $(0, 600)$, $(-800, 0)$.



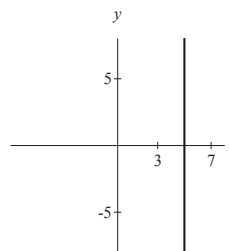
85. Intercepts are $(0, 0.0025)$, $(0.005, 0)$.



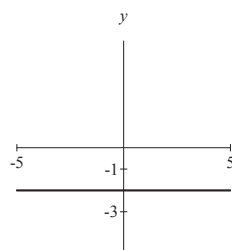
86. Intercepts are $(0, -0.3)$, $(0.5, 0)$.



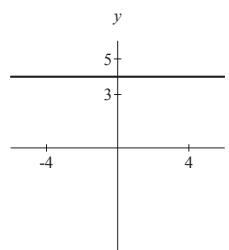
87. $x = 5$



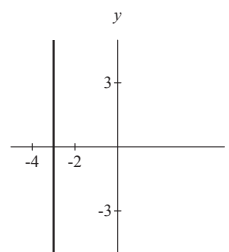
88. $y = -2$



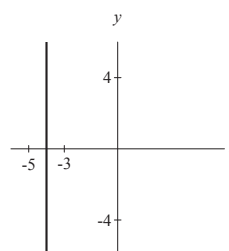
89. $y = 4$



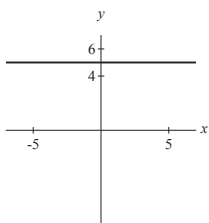
90. $x = -3$



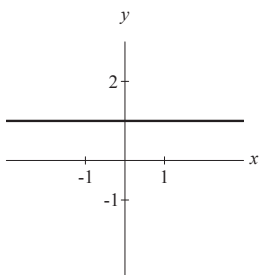
91. $x = -4$



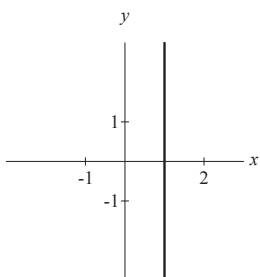
92. $y = 5$



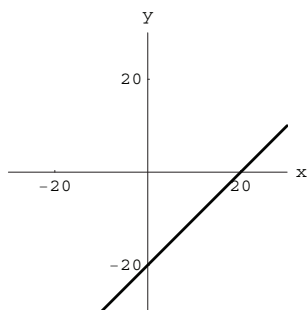
93. Solving for y , we have $y = 1$.



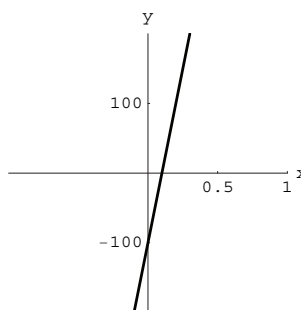
94. Solving for x , we get $x = 1$.



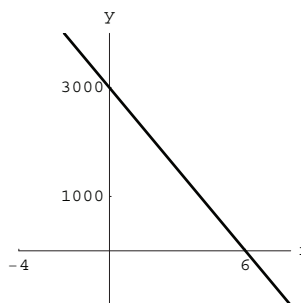
95. $y = x - 20$ goes through $(0, -20)$, $(20, 0)$.



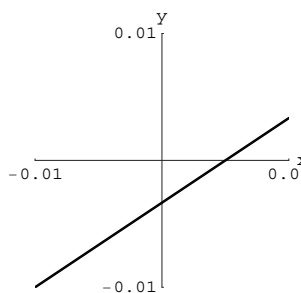
96. $y = 999x - 100$ goes through $(0, -100)$, $(100/999, 0)$.



97. $y = 3000 - 500x$ goes through $(0, 3000)$, $(6, 0)$.



98. $y = \frac{1}{300}(200x - 1)$ goes through $(0, -1/300)$, $(1/200, 0)$.



99. The hypotenuse is $\sqrt{6^2 + 8^2} = \sqrt{100} = 10$.

100. The other leg is $\sqrt{10^2 - 4^2} = \sqrt{84} = 2\sqrt{21}$ ft.

101. a) Let r be the radius of the smaller circle. Consider the right triangle with vertices at the origin, another vertex at the center of a smaller circle, and a third vertex at the center of the circle of radius 1. By the Pythagorean Theorem, we obtain

$$\begin{aligned} 1 + (2 - r)^2 &= (1 + r)^2 \\ 5 - 4r &= 1 + 2r \end{aligned}$$

$$\begin{aligned} 4 &= 6r \\ r &= \frac{2}{3}. \end{aligned}$$

The diameter of the smaller circle is $2r = \frac{4}{3}$.

- b) The smallest circles are centered at $(\pm r, 0)$ or $(\pm 4/3, 0)$. The equations of the circles are

$$\left(x - \frac{4}{3}\right)^2 + y^2 = \frac{4}{9}$$

and

$$\left(x + \frac{4}{3}\right)^2 + y^2 = \frac{4}{9}$$

- 102.** Draw a right triangle with vertices at the centers of the circles, and another vertex at a point of intersection of the two circles. The legs of the right triangle are 5 and 12. By the Pythagorean theorem, the hypotenuse is $\sqrt{5^2 + 12^2} = 13$.

- 103.** Let $C(h, k)$ and r be the center and radius of the smallest circle, respectively. Then $k = -r$. We consider two right triangles each of which has a vertex at C .

The right triangles have sides that are perpendicular to the coordinate axes. Also, one side of each right triangle passes through the center of a larger circle.

Applying the Pythagorean Theorem, we list a system of equations

$$(r + 1)^2 = h^2 + (1 - r)^2$$

$$(2 - r)^2 = h^2 + r^2.$$

The solutions are $r = 1/2$, $h = \sqrt{2}$, and $k = -r = -1/2$.

The equation of the smallest circle is

$$(x - \sqrt{2})^2 + (y + 1/2)^2 = 1/4.$$

- 104.** We apply symmetry to the centers of the remaining three circles. From the answer or equation in Exercise 103, the equations of the remaining circles are

$$(x - \sqrt{2})^2 + (y - 1/2)^2 = 1/4$$

$$(x + \sqrt{2})^2 + (y - 1/2)^2 = 1/4$$

$$(x + \sqrt{2})^2 + (y + 1/2)^2 = 1/4.$$

- 105.** The midpoint of $(0, 20.8)$ and $(48, 27.4)$ is

$$\left(\frac{0 + 48}{2}, \frac{20.8 + 27.4}{2}\right) = (24, 24.1).$$

In 1994 ($= 1970 + 24$), the median age at first marriage was 24.1 years.

- 106.** a) If $h = 0$, then $0 = 0.229n + 5.203$.

Then $n = -5.203/0.229 \approx -22.72$.

The n -intercept is

$$(-22.72, 0).$$

There were no unmarried couples in 1977 ($\approx 2000 - 22.7$). Nonsense.

- b) If $n = 0$, then $h = 0.229(0) + 5.203 = 5.203$. The h -intercept is $(0, 5.203)$. In 2000, there were 5,203,000 unmarried-couple households.

- 107.** The distance between $(10, 0)$ and $(0, 0)$ is 10.

The distance between $(1, 3)$ and the origin is $\sqrt{10}$. If two points have integer coordinates, then the distance between them is of the form $\sqrt{s^2 + t^2}$ where $s^2, t^2 \in \{0, 1, 2^2, 3^2, 4^2, \dots\} = \{0, 1, 4, 9, 16, \dots\}$.

Note, there are no numbers s^2 and t^2 in $\{0, 1, 4, 9, 16, \dots\}$ satisfying $s^2 + t^2 = 19$.

Thus, one cannot find two points with integer coordinates whose distance between them is $\sqrt{19}$.

- 108.** One can assume the vertices of the right triangle are $A(0, 0)$, $B(1, \sqrt{3})$, and $C(1, 0)$.

The midpoint of the hypotenuse AB is

$$\left(\frac{1}{2}, \frac{\sqrt{3}}{2}\right).$$

The distance between the midpoint and C is $\sqrt{\left(\frac{1}{2} - 1\right)^2 + \left(\frac{\sqrt{3}}{2} - 0\right)^2} = 1$, which is also the distance from the midpoint to A , and the distance from the midpoint to B .

- 111.** On day 1, break off a 1-dollar piece and pay the gardener.

On day 2, break off a 2-dollar and pay the gardener. The gardener will give you back your change which is a 1-dollar piece.

On day 3, you pay the gardener with the 1-dollar piece you received as change from the previous day.

On day 4, pay the gardener with the 4-dollar bar. The gardener will give you back your change which will consist of a 1-dollar piece and a 2-dollar piece.

On day 5, you pay the gardener with the 1-dollar piece you received as change from the previous day.

On day 6, pay the gardener with the 2-dollar piece you received as change from day 4. The gardener will give you back your change which is a 1-dollar piece.

On day 7, pay the gardener with the 1-dollar piece you received as change from day 6.

- 112.** Let $\triangle ABC$ be a right triangle with vertices at $A(2, 7)$, $B(0, -3)$, and $C(6, 1)$. Notice, the midpoints of the sides of $\triangle ABC$ are $(3, -1)$, $(4, 4)$ and $(1, 2)$. The area of $\triangle ABC$ is

$$\begin{aligned}\frac{1}{2}\overline{AC} \times \overline{BC} &= \frac{1}{2}\sqrt{4^2 + 6^2}\sqrt{6^2 + 4^2} \\ &= \frac{1}{2}(52) = 26.\end{aligned}$$

P.1 Pop Quiz

- 1.** The distance is $\sqrt{16 + 4} = \sqrt{20} = 2\sqrt{5}$.

- 2.** Center $(3, -5)$, radius 9

- 3.** Completing the square, we find

$$\begin{aligned}(x^2 + 4x + 4) + (y^2 - 10y + 25) &= -28 + 4 + 25 \\ (x + 2)^2 + (y - 5)^2 &= 1.\end{aligned}$$

The center is $(-2, 5)$ and the radius is 1.

- 4.** The distance between $(3, 4)$ and the origin is 5, which is the radius. The circle is given by $(x - 3)^2 + (y - 4)^2 = 25$.

- 5.** By setting $x = 0$ and $y = 0$ in $2x - 3y = 12$ we find $-3y = 12$ and $2x = 12$, respectively. Since $y = -4$ and $x = 6$ are the solutions of the two equations, the intercepts are $(0, -4)$ and $(6, 0)$.

- 6.** $(5, -1)$

For Thought

- True, since the number of gallons purchased is 20 divided by the price per gallon.
- 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.
- False, since $\{(1, 2), (1, 3)\}$ is not a function.
- True
- True
- True
- False, the domain is the set of all real numbers.
- True
- True, since $f(0) = \frac{0 - 2}{0 + 2} = -1$.
- True, since if $a - 5 = 0$ then $a = 5$.

P.2 Exercises

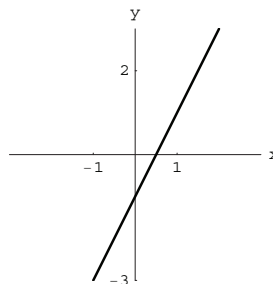
- function
- independent, dependent
- domain, range
- parabola
- function
- function
- Note, $b = 2\pi a$ is equivalent to $a = \frac{b}{2\pi}$. Then a is a function of b , and b is a function of a .
- Note, $b = 2(5 + a)$ is equivalent to $a = \frac{b - 10}{2}$. Then a is a function of b , and b is a function of a .
- 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 .

10. Since different U.S. coins have different diameters, then a is a function of b , and b is a function of a .
11. 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 .
12. 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.
13. 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.
14. 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.
15. Since 1 in ≈ 2.54 cm, a is a function of b and b is a function of a .
16. 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 47 cents to mail first class, b is not a function of a .
17. Since $b = a^3$ and $a = \sqrt[3]{b}$, we get that b is a function of a , and a is a function of b .
18. Since $b = a^4$ and $a = \pm \sqrt[4]{b}$, we get that b is a function of a , but a is not a function of b .
19. Since $b = |a|$, we get b is a function of a . Since $a = \pm b$, we find a is not a function of b .
20. Note, $b = \sqrt{a}$ since $a \geq 0$, and $a = b^2$. Thus, b is a function of a , and a is a function of b .
21. $A = s^2$ 22. $s = \sqrt{A}$ 23. $s = \frac{\sqrt{2}d}{2}$

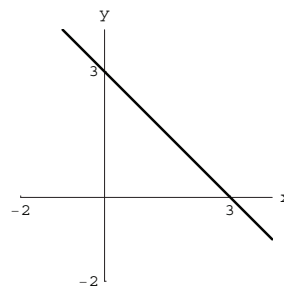
24. $d = s\sqrt{2}$ 25. $P = 4s$ 26. $s = P/4$

27. $A = P^2/16$ 28. $d = \sqrt{2A}$

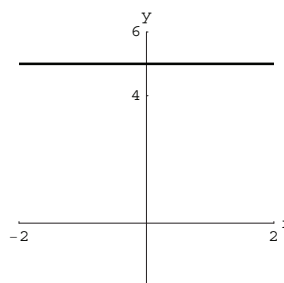
29. $y = 2x - 1$ has domain $(-\infty, \infty)$ and range $(-\infty, \infty)$, some points are $(0, -1)$ and $(1, 1)$



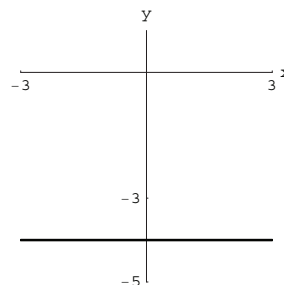
30. $y = -x + 3$ has domain $(-\infty, \infty)$ and range $(-\infty, \infty)$, some points are $(0, 3)$ and $(3, 0)$



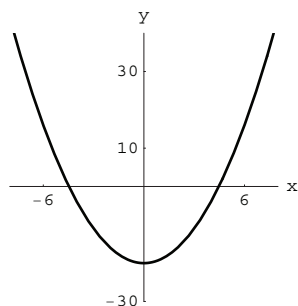
31. $y = 5$ has domain $(-\infty, \infty)$ and range $\{5\}$, some points are $(0, 5)$ and $(1, 5)$



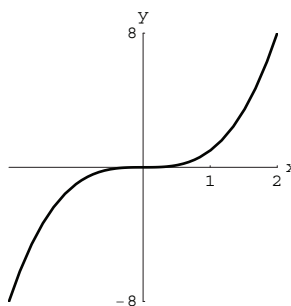
32. $y = -4$ has domain $(-\infty, \infty)$ and range $\{-4\}$, some points are $(0, -4)$ and $(1, -4)$



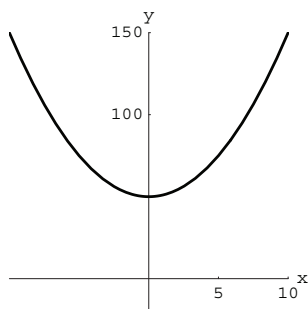
- 33.** $y = x^2 - 20$ has domain $(-\infty, \infty)$ and range $[-20, \infty)$, some points are $(0, -20)$ and $(6, 16)$



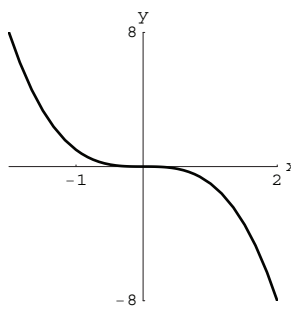
- 37.** $y = x^3$ has domain $(-\infty, \infty)$ and range $(-\infty, \infty)$, some points are $(0, 0)$ and $(2, 8)$



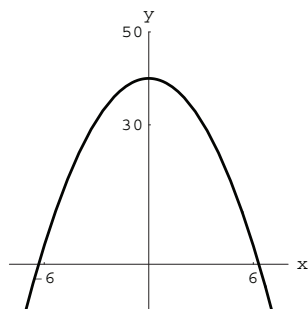
- 34.** $y = x^2 + 50$ has domain $(-\infty, \infty)$ and range $[50, \infty)$, some points are $(0, 50)$ and $(5, 75)$



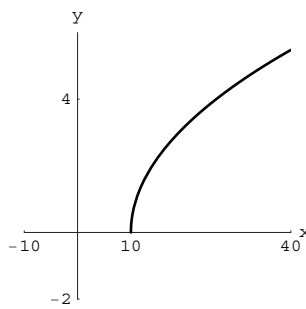
- 38.** $y = -x^3$ has domain $(-\infty, \infty)$ and range $(-\infty, \infty)$, some points are $(0, 0)$ and $(0, -8)$



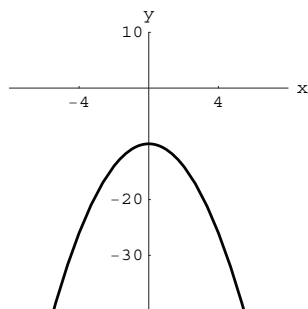
- 35.** $y = 40 - x^2$ has domain $(-\infty, \infty)$ and range $(-\infty, 40]$, some points are $(0, 40)$ and $(6, 4)$



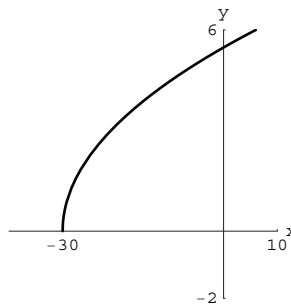
- 39.** $y = \sqrt{x - 10}$ has domain $[10, \infty)$ and range $[0, \infty)$, some points are $(10, 0)$ and $(14, 2)$



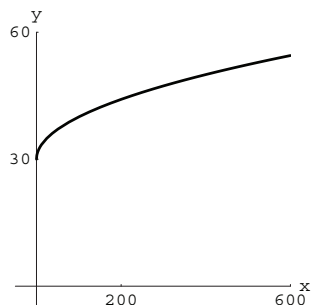
- 36.** $y = -10 - x^2$ has domain $(-\infty, \infty)$ and range $(-\infty, -10]$, some points are $(0, -10)$ and $(4, -26)$



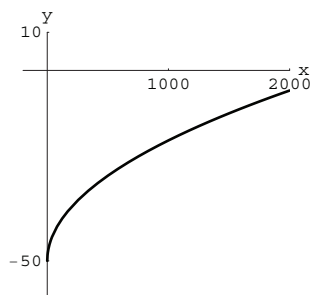
- 40.** $y = \sqrt{x + 30}$ has domain $[-30, \infty)$ and range $[0, \infty)$, some points are $(-30, 0)$ and $(-26, 2)$



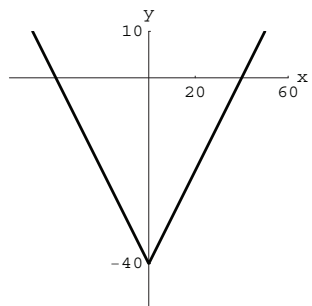
41. $y = \sqrt{x} + 30$ has domain $[0, \infty)$ and range $[30, \infty)$, some points are $(0, 30)$ and $(400, 50)$



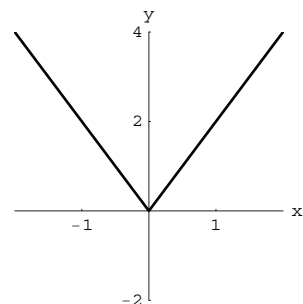
42. $y = \sqrt{x} - 50$ has domain $[0, \infty)$ and range $[-50, \infty)$, some points are $(0, -50)$ and $(900, -20)$



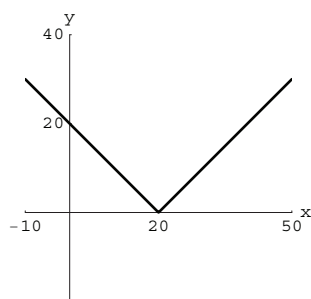
43. $y = |x| - 40$ has domain $(-\infty, \infty)$ and range $[-40, \infty)$, some points are $(0, -40)$ and $(40, 0)$



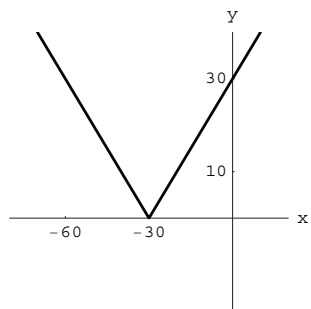
44. $y = 2|x|$ has domain $(-\infty, \infty)$ and range $[0, \infty)$, some points are $(0, 0)$ and $(1, 2)$



45. $y = |x - 20|$ has domain $(-\infty, \infty)$ and range $[0, \infty)$, some points are $(0, 20)$ and $(20, 0)$



46. $y = |x + 30|$ has domain $(-\infty, \infty)$ and range $[0, \infty)$, some points are $(0, 30)$ and $(-30, 0)$



47. $3 \cdot 4 - 2 = 10$ 48. $3(16) + 4 = 52$

49. $-4 - 2 = -6$ 50. $-8 - 2 = -10$

51. $|8| = 8$ 52. $|-1| = 1$

53. $4 + (-6) = -2$ 54. $24 \cdot 6 = 144$

55. $80 - 2 = 78$ 56. $2/2 = 1$

57. $3a^2 - a$ 58. $4b - 2$

59. $f(-x) = 3(-x)^2 - (-x) = 3x^2 + x$

60. $g(-x) = 4(-x) - 2 = -4x - 2$

61. Factoring, we get $x(3x - 1) + 0$. So $x = 0, 1/3$.

62. Since $4x - 2 = 3$, we get $x = 5/4$.

63. Since $|a + 3| = 4$ is equivalent to $a + 3 = 4$ or $a + 3 = -4$, we have $a = 1, -7$.

64. Since $3t^2 - t - 10 = (t - 2)(3t + 5) = 0$, we find $t = 2, -5/3$.

65. $C = 353n$

66. $P = 580n$

67. $C = 35n + 50$

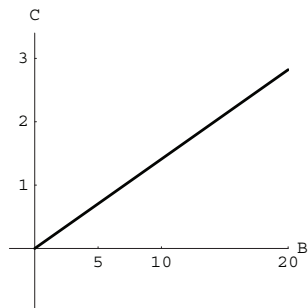
68. $C = 2.50 + 0.50n$

69. We find

$$C = \frac{4B}{\sqrt[3]{D}} = \frac{4(12 + 11/12)}{\sqrt[3]{22,800}} \approx 1.822$$

and a sketch of the graph of $C = \frac{4B}{\sqrt[3]{22,800}}$

is given below.



70. Solving for B , we get

$$\begin{aligned} \frac{4B}{\sqrt[3]{22,800}} &< 2 \\ B &< \frac{\sqrt[3]{22,800}}{2} \\ B &< 14 \text{ ft, } 2 \text{ in.} \end{aligned}$$

Then the maximum displacement is 14 ft, 2 in.

With D fixed, we get that C becomes larger as the beam B becomes larger. Thus, a boat is more likely to capsize as the beam gets larger.

71. Let $N = 2$, $B = 3.498$, and $S = 4.250$. Then

$$\begin{aligned} D &= \frac{\pi}{4} B^2 \cdot S \cdot N \\ &= 81.686 \text{ in.}^3 \end{aligned}$$

Then $D \approx 81.7 \text{ in.}^3$.

72. Let $N = 2$, $B = 3.518$, and $S = 4.250$. Then

$$\begin{aligned} D &= \frac{\pi}{4} B^2 \cdot S \cdot N \\ &= 82.622 \text{ in.}^3 \end{aligned}$$

Using the unrounded answer to Exercise 71, the difference in the displacement is

$$82.622 - 81.686 \approx 0.94 \text{ in.}^3.$$

73. Solving for B ,

$$D = \frac{\pi}{4} B^2 \cdot S \cdot N$$

$$\frac{4D}{\pi S \cdot N} = B^2$$

$$B = 2\sqrt{\frac{D}{\pi S \cdot N}}.$$

74. Solving for V ,

$$CR = 1 + \frac{\pi B^2 \cdot S}{4V}$$

$$CR - 1 = \frac{\pi B^2 \cdot S}{4V}$$

$$\frac{1}{CR - 1} = \frac{4V}{\pi B^2 \cdot S}$$

$$V = \frac{\pi B^2 \cdot S}{4(CR - 1)}.$$

75. Pythagorean, legs, hypotenuse

76. circle, radius, center

$$77. \sqrt{(2+3)^2 + (-4+6)^2} = \sqrt{29}$$

$$78. \left(\frac{4-6}{2}, \frac{-8+16}{2} \right) = (-1, 4)$$

79. If we replace $x = 0$ in $4x - 6y = 40$, then $-6y = 40$ or $y = -20/3$. The y -intercept is $(0, -20/3)$.

If we replace $y = 0$ in $4x - 6y = 40$, then $4x = 40$ or $x = 10$. The x -intercept is $(10, 0)$.

$$80. \text{ The diagonal is } \sqrt{3^2 + 7^2} = \sqrt{58} \text{ ft.}$$

81. Rewriting the equation, we find

$$\frac{1}{3^3} \cdot 3^{100} \cdot \frac{1}{3^4} \cdot 3^{2x} = \frac{1}{3} \cdot 3^x$$

$$\frac{1}{3^3} \cdot 3^{100} \cdot \frac{1}{3^4} \cdot 3^{2x} = 3^{x-1}$$

$$3^{2x+93} = 3^{x-1}$$

$$2x + 93 = x - 1$$

$$x = -94.$$

82. First, $9 = (a+b)^2 = (a^2+b^2)+2ab = 89+2ab$.
Then $ab = -40$. Thus,

$$\begin{aligned} a^3 + b^3 &= (a+b)(a^2+b^2-ab) \\ &= 3(89+40) \\ &= 387. \end{aligned}$$

P.2 Pop Quiz

1. Yes, since $r \geq 0$ and $r = \sqrt{A/\pi}$
2. Since $A = s^2$ and $s \geq 0$, we obtain $s = \sqrt{A}$.
3. No, since $b = \pm a$.
4. $[1, \infty)$
5. $[2, \infty)$
6. $f(3) = 3(3) + 6 = 15$
7. We find

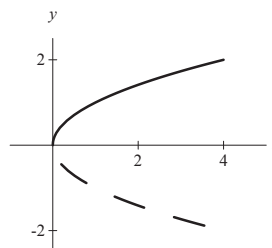
$$\begin{aligned} 2a - 4 &= 10 \\ 2a &= 14 \\ a &= 7. \end{aligned}$$

For Thought

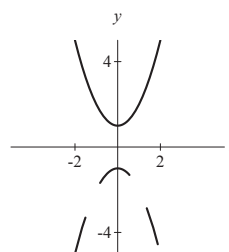
1. False, it is a reflection in the y-axis.
2. False, the graph of $y = x^2 - 4$ is shifted down 4 units from the graph of $y = x^2$.
3. False, rather it is a left translation.
4. True
5. True
6. False, the down shift should come after the reflection.
7. True
8. False, since the domains are different.
9. True
10. True, since $f(-x) = -f(x)$ where $f(x) = x^3$.

P.3 Exercises

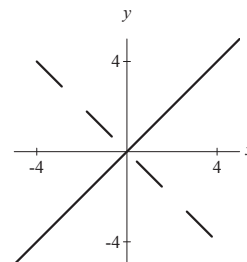
1. rigid
2. nonrigid
3. reflection
4. upward translation, downward translation
5. right, left
6. stretching, shrinking
7. odd
8. even
9. transformation
10. family
11. $f(x) = \sqrt{x}$, $g(x) = -\sqrt{x}$



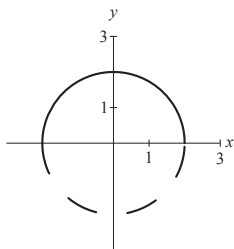
12. $f(x) = x^2 + 1$, $g(x) = -x^2 - 1$



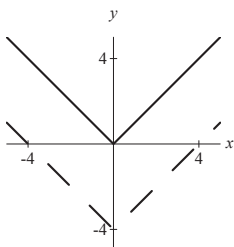
13. $y = x$, $y = -x$



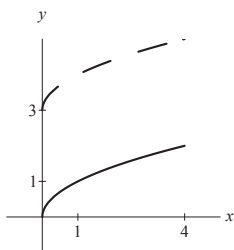
14. $y = \sqrt{4 - x^2}$, $y = -\sqrt{4 - x^2}$



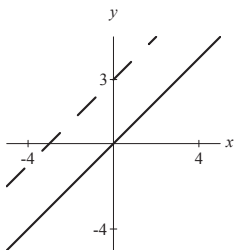
15. $f(x) = |x|$, $g(x) = |x| - 4$



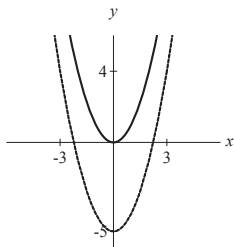
16. $f(x) = \sqrt{x}$, $g(x) = \sqrt{x} + 3$



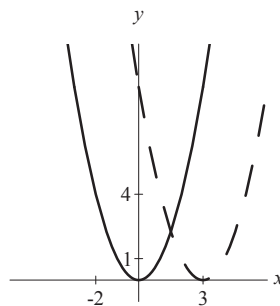
17. $f(x) = x$, $g(x) = x + 3$



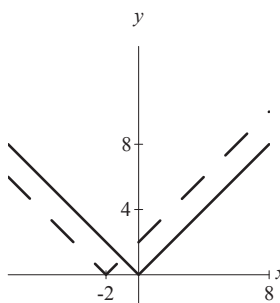
18. $f(x) = x^2$, $g(x) = x^2 - 5$



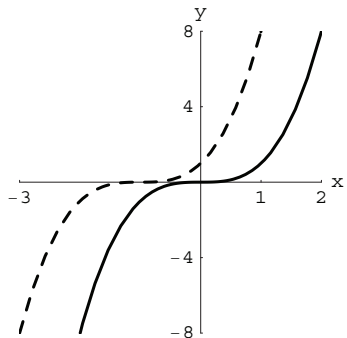
19. $y = x^2$, $y = (x - 3)^2$



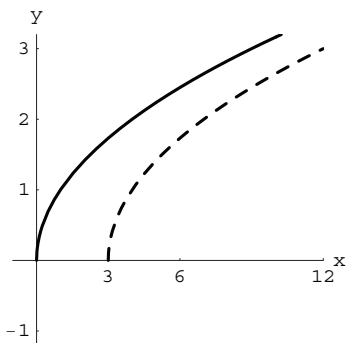
20. $y = |x|$, $y = |x + 2|$



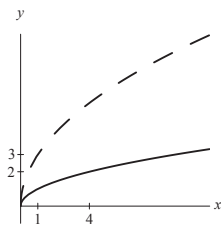
21. $f(x) = x^3$, $g(x) = (x + 1)^3$



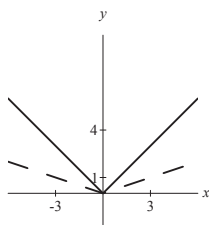
22. $f(x) = \sqrt{x}$, $g(x) = \sqrt{x - 3}$



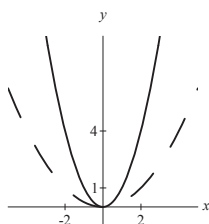
23. $y = \sqrt{x}, y = 3\sqrt{x}$



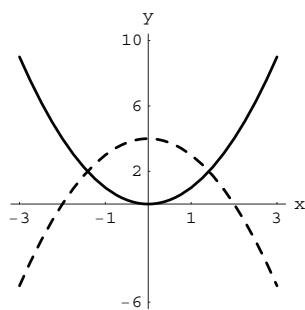
24. $y = |x|, y = \frac{1}{3}|x|$



25. $y = x^2, y = \frac{1}{4}x^2$



26. $y = x^2, y = 4 - x^2$



27. g 28. h 29. b 30. d

31. c 32. a 33. f 34. e

35. $y = (x - 10)^2 + 4$

36. $y = \sqrt{x + 5} - 12$

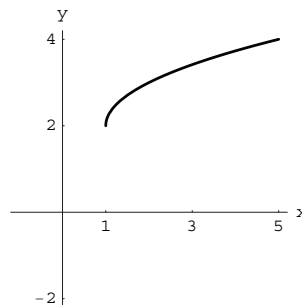
37. $y = -3|x - 7| + 9$

38. $y = -2(x + 6) - 8$ or $y = -2x - 20$

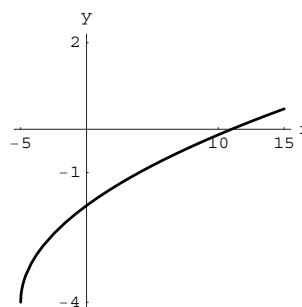
39. $y = -(3\sqrt{x} + 5)$ or $y = -3\sqrt{x} - 5$

40. $y = -((x - 13)^2 - 6)$ or $y = -(x - 13)^2 + 6$

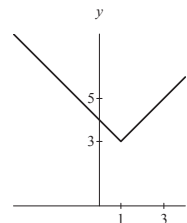
41. $y = \sqrt{x - 1} + 2$; right by 1, up by 2



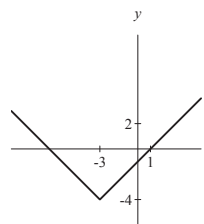
42. $y = \sqrt{x + 5} - 4$; left by 5, down by 4



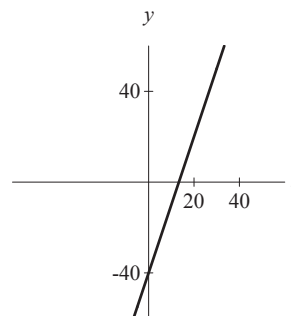
43. $y = |x - 1| + 3$; right by 1, up by 3



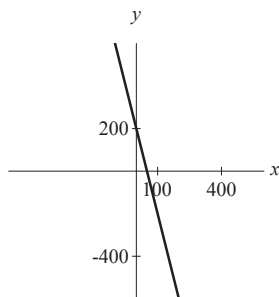
44. $y = |x + 3| - 4$; left by 3, down by 4



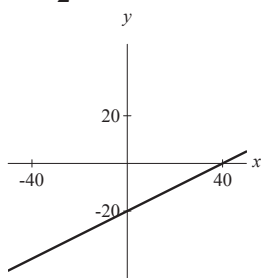
45. $y = 3x - 40$



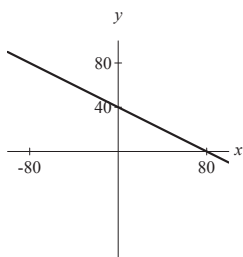
46. $y = -4x + 200$



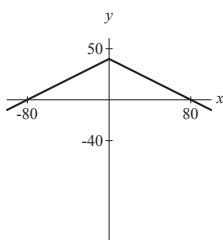
47. $y = \frac{1}{2}x - 20$



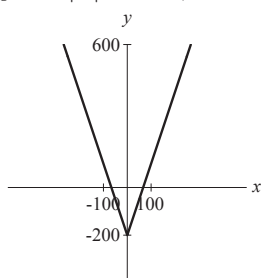
48. $y = -\frac{1}{2}x + 40$



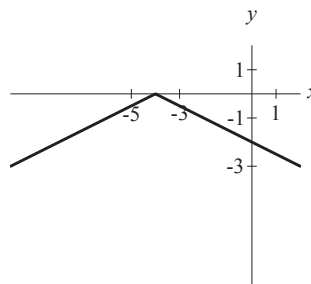
49. $y = -\frac{1}{2}|x| + 40$, shrink by 1/2,
reflect about x -axis, up by 40



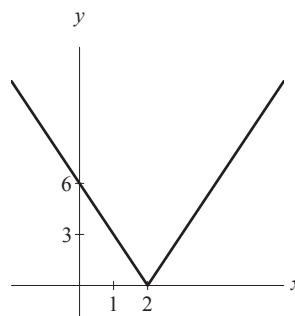
50. $y = 3|x| - 200$, stretch by 3, down by 200



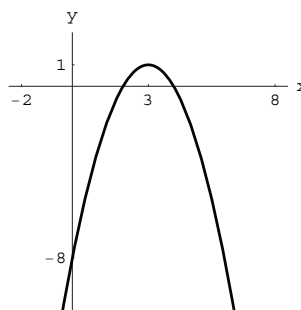
51. $y = -\frac{1}{2}|x + 4|$, left by 4,
reflect about x -axis, shrink by 1/2



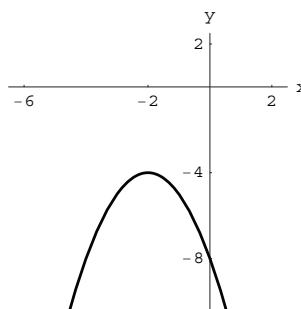
52. $y = 3|x - 2|$, right by 2, stretch by 3



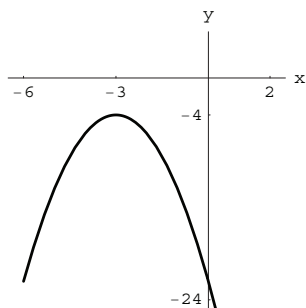
53. $y = -(x - 3)^2 + 1$; right by 3,
reflect about x -axis, up by 1



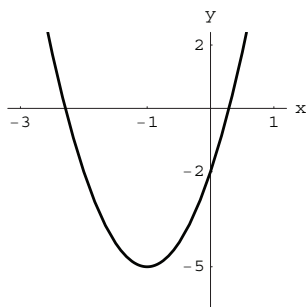
54. $y = -(x + 2)^2 - 4$; left by 2,
reflect about x -axis, down by 4



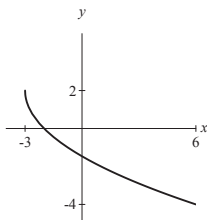
55. $y = -2(x + 3)^2 - 4$; left by 3,
stretch by 2, reflect about x -axis, down by 4



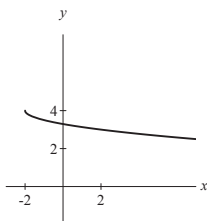
56. $y = 3(x + 1)^2 - 5$; left by 1,
stretch by 3, down by 5



57. $y = -2\sqrt{x + 3} + 2$, left by 3, stretch by 2,
reflect about x -axis, up by 2



58. $y = -\frac{1}{2}\sqrt{x + 2} + 4$, left by 2, shrink by $1/2$,
reflect about x -axis, up by 4



59. Symmetric about y -axis, even function
since $f(-x) = f(x)$

60. Symmetric about y -axis, even function
since $f(-x) = f(x)$

61. No symmetry, neither even nor odd
since $f(-x) \neq f(x)$ and $f(-x) \neq -f(x)$

62. Symmetric about the origin, odd function
since $f(-x) = -f(x)$

63. Neither symmetry, neither even nor odd since
 $f(-x) \neq f(x)$ and $f(-x) \neq -f(x)$

64. Neither symmetry, neither even nor odd
since $f(-x) \neq f(x)$ and $f(-x) \neq -f(x)$

65. No symmetry, not an even or odd function
since $f(-x) \neq f(x)$ and $f(-x) \neq -f(x)$

66. Symmetric about the y -axis, even function
since $f(-x) = f(x)$

67. Symmetric about the origin, odd function
since $f(-x) = -f(x)$

68. Symmetric about the origin, odd function
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69. No symmetry, not an even or odd function
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since $f(-x) \neq f(x)$ and $f(-x) \neq -f(x)$

72. Symmetric about the y -axis, even function
since $f(-x) = f(x)$

73. Neither symmetry, not an even or odd function
since $f(-x) \neq f(x)$ and $f(-x) \neq -f(x)$

74. Symmetric about the y -axis, even function
since $f(-x) = f(x)$

75. Symmetric about the y -axis, even function
since $f(-x) = f(x)$

76. Symmetric about the y -axis, even function
since $f(-x) = f(x)$

since $f(-x) = f(x)$

since $f(-x) = f(x)$

77. e 78. a 79. g 80. h

81. b 82. d 83. c 84. f

85. $N(x) = x + 2000$

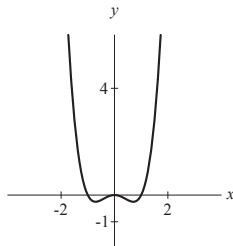
86. $N(x) = 1.05x + 3000$. Yes, if the merit increase is followed by the cost of living raise then the new salary becomes higher and is
 $N'(x) = 1.05(x + 3000) = 1.05x + 3150$.

87. If inflation rate is less than 50%, then
 $1 - \sqrt{x} < \frac{1}{2}$. This simplifies to $\frac{1}{2} < \sqrt{x}$. After squaring we have $\frac{1}{4} < x$ and so $x > 25\%$.

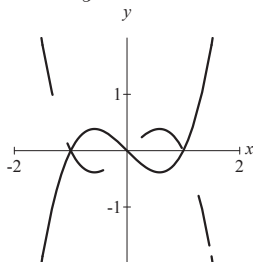
88. If production is at least 28 windows, then $1.75\sqrt{x} \geq 28$. They need at least
 $x = \left(\frac{28}{1.75}\right)^2 = 256$ hrs.

89.

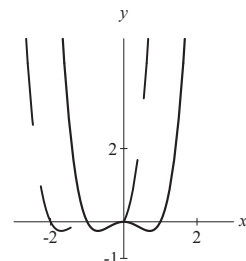
- (a) Both functions are symmetric about the y -axis, and the graphs are identical.



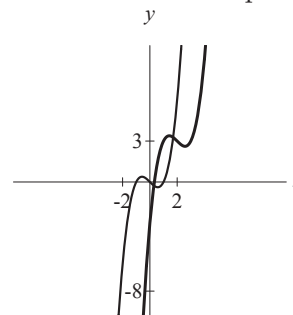
- (b) One graph is a reflection of the other about the y -axis, and both are symmetric about the y -axis.



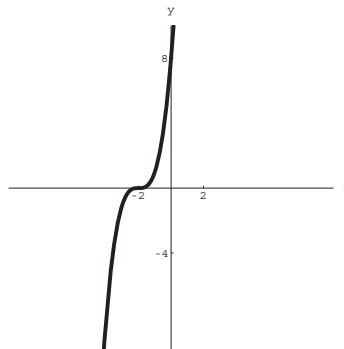
- (c) The second graph is obtained by translating the first one to the left by 1 unit.



- (d) The second graph is obtained by translating the first one to the right by 2 units and 3 units up.



90. The graph of $y = x^3 + 6x^2 + 12x + 8$ or equivalently $y = (x + 2)^3$ can be obtained by shifting the graph of $y = x^3$ to the left by 2 units.



91. $x^2 + y^2 = 1$

92. $y = 5$

93. $x = 4$

94. If A is the area and s is the length of a side, then $A = s^2$.

95. $f(6) = 2(36) - 3(6) = 72 - 18 = 54$
 $f(-x) = 2(-x)^2 - 3(-x) = 2x^2 + 3x$

96. Solve for a :

$$\begin{aligned} 2a^2 + 1 &= 9 \\ 2a^2 &= 8 \\ a^2 &= 4 \\ a &= \pm 2. \end{aligned}$$

97. Draw the numbers in $\{1, 2, 3, \dots, 999\}$ that can be written in the form

$$(2n + 1) \cdot 2^{2m}$$

for $n, m \geq 0$. These means that you will have drawn 666 numbers. Then the 667th number you will draw has the form

$$(2n + 1) \cdot 2^{2m+1}$$

which must be twice one of the first 666 numbers.

98. Let $A(x_1, 2)$ and $B(x_2, 2)$ be the other two opposite vertices where $x_1 < x_2$. Since the sides at B are perpendicular, the slopes are negative reciprocals, i.e.,

$$\frac{3}{3 - x_2} = -\frac{x_2 - 1}{3}.$$

Solving, $x_2 = 2 + \sqrt{10}$. Since the distance AB is the same as the distance between $(1, -1)$ and $(3, 5)$, we obtain

$$\begin{aligned} x_2 - x_1 &= \sqrt{40} = 2\sqrt{10} \\ x_1 &= x_2 - 2\sqrt{10} \\ x_1 &= (2 + \sqrt{10}) - 2\sqrt{10} \\ x_1 &= 2 - \sqrt{10}. \end{aligned}$$

Then the other vertices are $(2 \pm \sqrt{10}, 2)$.

P.3 Pop Quiz

1. $y = \sqrt{x} + 8$
2. $y = (x - 9)^2$
3. $y = (-x)^3$ or $y = -x^3$
4. Domain $[1, \infty)$, range $(-\infty, 5]$
5. $y = -3(x - 6)^2 + 4$
6. Even function

For Thought

1. True, since $A = P^2/16$.
2. False, rather $y = (x - 1)^2 = x^2 - 2x + 1$.
3. False, rather $(f \circ g)(x) = \sqrt{x - 2}$.
4. True
5. False, since $(h \circ g)(x) = x^2 - 9$.
6. False, rather $f^{-1}(x) = \frac{1}{2}x - \frac{1}{2}$.
7. True
8. False; g^{-1} does not exist since the graph of g which is a parabola fails the horizontal line test.
9. False, since $y = x^2$ is a function which does not have an inverse function.
10. True

P.4 Exercises

1. composition
2. one-to-one
3. invertible
4. inverse
5. switch-and-solve
6. symmetric
7. $y = 2(3x + 1) - 3 = 6x - 1$
8. $y = -4(-3x - 2) - 1 = 12x + 7$
9. $y = (x^2 + 6x + 9) - 2 = x^2 + 6x + 7$
10. $y = 3(x^2 - 2x + 1) - 3 = 3x^2 - 6x$
11. $y = 3 \cdot \frac{x + 1}{3} - 1 = x + 1 - 1 = x$
12. $y = 2 \left(\frac{1}{2}x - \frac{5}{2} \right) + 5 = x - 5 + 5 = x$
13. $y = 2 \cdot \frac{x + 1}{2} - 1 = x + 1 - 1 = x$
14. $y = \frac{(5x - 1) + 1}{5} = \frac{5x}{5} = x$

15. $f(2) = 5$ 16. $g(-4) = 17$

17. $f(2) = 5$ 18. $h(-22) = -7$

19. $f(17) = 3(17) - 1 = 50$

20. $g\left(-\frac{8}{3}\right) = \frac{64}{9} + 1 = \frac{73}{9}$

21. $3(x^2 + 1) - 1 = 3x^2 + 2$

22. $(3x - 1)^2 + 1 = 9x^2 - 6x + 2$

23. $(3x - 1)^2 + 1 = 9x^2 - 6x + 2$

24. $3(x^2 + 1) - 1 = 3x^2 + 2$ 25. $\frac{x^2 + 2}{3}$

26. $\frac{x^2 + 2x + 1}{9} + 1 = \frac{1}{9}x^2 + \frac{2}{9}x + \frac{10}{9}$

27. $F = g \circ h$ 28. $G = g \circ f$

29. $H = h \circ g$ 30. $M = f \circ g$

31. $N = f \circ h$ 32. $R = h \circ f$

33. Interchange x and y then solve for y .

$$\begin{aligned} x &= 3y - 7 \\ \frac{x+7}{3} &= y \\ \frac{x+7}{3} &= f^{-1}(x) \end{aligned}$$

34. Interchange x and y then solve for y .

$$\begin{aligned} x &= -2y + 5 \\ 2y &= 5 - x \\ f^{-1}(x) &= \frac{5 - x}{2} \\ f^{-1}(x) &= \frac{x - 5}{-2} \end{aligned}$$

35. Interchange x and y then solve for y .

$$\begin{aligned} x &= 2 + \sqrt{y - 3} \quad \text{for } x \geq 2 \\ (x - 2)^2 &= y - 3 \quad \text{for } x \geq 2 \\ f^{-1}(x) &= (x - 2)^2 + 3 \quad \text{for } x \geq 2 \end{aligned}$$

36. Interchange x and y then solve for y .

$$\begin{aligned} x &= \sqrt{3y - 1} \quad \text{for } x \geq 0 \\ x^2 + 1 &= 3y \quad \text{for } x \geq 0 \\ f^{-1}(x) &= \frac{x^2 + 1}{3} \quad \text{for } x \geq 0 \end{aligned}$$

37. Interchange x and y then solve for y .

$$\begin{aligned} x &= -y - 9 \\ y &= -x - 9 \\ f^{-1}(x) &= -x - 9 \end{aligned}$$

38. Interchange x and y then solve for y .

$$\begin{aligned} x &= -y + 3 \\ y &= -x + 3 \\ f^{-1}(x) &= -x + 3 \end{aligned}$$

39. Interchange x and y then solve for y .

$$\begin{aligned} x &= -\frac{1}{y} \\ xy &= -1 \\ f^{-1}(x) &= -\frac{1}{x} \end{aligned}$$

40. Clearly $f^{-1}(x) = x$

41. Interchange x and y then solve for y .

$$\begin{aligned} x &= \sqrt[3]{y - 9} + 5 \\ x - 5 &= \sqrt[3]{y - 9} \\ (x - 5)^3 &= y - 9 \\ f^{-1}(x) &= (x - 5)^3 + 9 \end{aligned}$$

42. Interchange x and y then solve for y .

$$\begin{aligned} x &= \sqrt[3]{\frac{y}{2}} + 5 \\ x - 5 &= \sqrt[3]{\frac{y}{2}} \\ (x - 5)^3 &= \frac{y}{2} \\ f^{-1}(x) &= 2(x - 5)^3 \end{aligned}$$

43. Interchange x and y then solve for y .

$$\begin{aligned} x &= (y - 2)^2 \quad x \geq 0 \\ \sqrt{x} &= y - 2 \\ f^{-1}(x) &= \sqrt{x} + 2 \end{aligned}$$

44. Interchange x and y then solve for y .

$$\begin{aligned} x &= (y + 3)^2 \quad x \geq 0 \\ \sqrt{x} &= y + 3 \\ f^{-1}(x) &= \sqrt{x} - 3 \end{aligned}$$

$$\begin{aligned} 45. (f^{-1} \circ f)(x) &= \frac{1}{2}(2x - 1) + \frac{1}{2} = x \text{ and} & &= \sqrt[5]{x^5 - 1 + 1} \\ & & &= \sqrt[5]{x^5} \\ (f \circ f^{-1})(x) &= 2\left(\frac{1}{2}x + \frac{1}{2}\right) - 1 = x & &(f^{-1} \circ f)(x) = x \end{aligned}$$

$$\begin{aligned} 46. (f^{-1} \circ f)(x) &= 3\left(\frac{x+1}{3}\right) - 1 = x \text{ and} & &\text{and} \\ (f \circ f^{-1})(x) &= \frac{(3x-1)+1}{3} = x & &(f \circ f^{-1})(x) = \sqrt[3]{\left(\sqrt[5]{x^3+1}\right)^5} - 1 \end{aligned}$$

$$\begin{aligned} 47. (f^{-1} \circ f)(x) &= 0.25(4x + 4) - 1 = x \text{ and} & &= \sqrt[3]{x^3 + 1 - 1} \\ (f \circ f^{-1})(x) &= 4(0.25x - 1) + 4 = x & &= \sqrt[3]{x^3} \end{aligned}$$

$$\begin{aligned} 48. (f^{-1} \circ f)(x) &= -0.2(20 - 5x) + 4 = x \text{ and} & &(f \circ f^{-1})(x) = x. \\ (f \circ f^{-1})(x) &= 20 - 5(-0.2x + 4) = x \end{aligned}$$

49. We obtain

$$\begin{aligned} (f^{-1} \circ f)(x) &= \frac{4 - \left(\sqrt[3]{4 - 3x}\right)^3}{3} \\ &= \frac{4 - (4 - 3x)}{3} \\ &= \frac{3x}{3} \\ (f^{-1} \circ f)(x) &= x \end{aligned}$$

and

$$\begin{aligned} (f \circ f^{-1})(x) &= \sqrt[3]{4 - 3\left(\frac{4 - x^3}{3}\right)} \\ &= \sqrt[3]{4 - (4 - x^3)} \\ &= \sqrt[3]{x^3} \\ (f \circ f^{-1})(x) &= x. \end{aligned}$$

50. We obtain

$$\begin{aligned} (f^{-1} \circ f)(x) &= \sqrt[3]{(x^3 + 5) - 5} \\ &= \sqrt[3]{x^3} \\ (f^{-1} \circ f)(x) &= x \end{aligned}$$

and

$$\begin{aligned} (f \circ f^{-1})(x) &= \left(\sqrt[3]{x - 5}\right)^3 + 5 \\ &= (x - 5) + 5 \\ (f \circ f^{-1})(x) &= x. \end{aligned}$$

51. We obtain

$$(f^{-1} \circ f)(x) = \sqrt[5]{\left(\sqrt[3]{x^5 - 1}\right)^3 + 1}$$

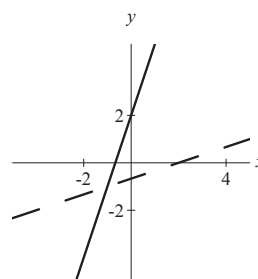
52. We find

$$\begin{aligned} (f^{-1} \circ f)(x) &= \left((x^{3/5} - 3) + 3\right)^{5/3} \\ &= \left(x^{3/5}\right)^{5/3} \\ (f^{-1} \circ f)(x) &= x \end{aligned}$$

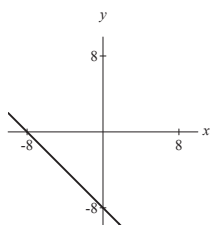
and

$$\begin{aligned} (f \circ f^{-1})(x) &= \left((x + 3)^{5/3}\right)^{3/5} - 3 \\ &= (x + 3) - 3 \\ (f \circ f^{-1})(x) &= x. \end{aligned}$$

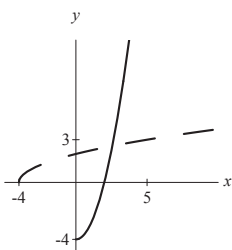
$$53. f^{-1}(x) = \frac{x - 2}{3}$$



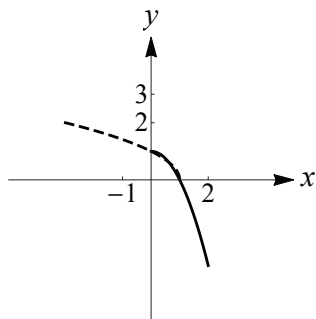
54. $f^{-1}(x) = -x - 8$



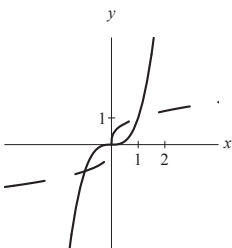
55. $f^{-1}(x) = \sqrt{x+4}$



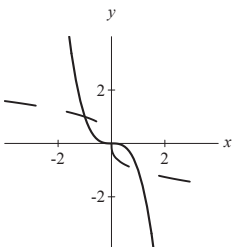
56. $f^{-1}(x) = \sqrt{1-x}$



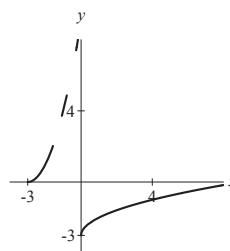
57. $f^{-1}(x) = \sqrt[3]{x}$



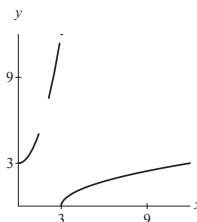
58. $f^{-1}(x) = -\sqrt[3]{x}$



59. $f^{-1}(x) = (x+3)^2$ for $x \geq -3$



60. $f^{-1}(x) = x^2 + 3$ for $x \geq 0$



61. The inverse is the composition of subtracting 2 and dividing by 5, i.e., $f^{-1}(x) = \frac{x-2}{5}$

62. The inverse is the composition of adding 1 and dividing by 0.5, i.e., $f^{-1}(x) = \frac{x+1}{0.5} = 2x+2$

63. The inverse is the composition of adding 88 and dividing by 2, i.e.,
 $f^{-1}(x) = \frac{x+88}{2} = \frac{1}{2}x+44$

64. The inverse is the composition of subtracting 99 and dividing by 3, i.e.,
 $f^{-1}(x) = \frac{x-99}{3} = \frac{1}{3}x-33$

65. The inverse is the composition of subtracting 4 and dividing by -3 , i.e.,
 $f^{-1}(x) = \frac{x-4}{-3} = -\frac{1}{3}x+\frac{4}{3}$

66. The inverse is the composition of adding 5 and dividing by -2 , i.e.,
 $f^{-1}(x) = \frac{x-5}{-2} = -\frac{1}{2}x+\frac{5}{2}$

67. The inverse is the composition of adding 9 and multiplying by 2, i.e.,
 $f^{-1}(x) = 2(x+9) = 2x+18$

68. The inverse is the composition of subtracting 6 and multiplying by 3, i.e.,
 $f^{-1}(x) = 3(x-6) = 3x-18$

- 69.** The inverse is the composition of subtracting 3 and taking the multiplicative inverse, i.e.,

$$f^{-1}(x) = \frac{1}{x-3}$$

- 70.** The inverse is the composition of taking the multiplicative inverse and subtracting 3, i.e.,

$$f^{-1}(x) = \frac{1}{x} - 3$$

- 71.** The inverse is the composition of adding 9 and raising an expression to the third power, i.e.,

$$f^{-1}(x) = (x+9)^3.$$

- 72.** The inverse is the composition of raising an expression to the third power and adding 9, i.e., $f^{-1}(x) = x^3 + 9$.

- 73.** The inverse is the composition of adding 7, dividing by 2, and taking the cube root, i.e.,

$$f^{-1}(x) = \sqrt[3]{\frac{x+7}{2}}.$$

- 74.** The inverse is the composition of subtracting by 4, multiplying by -1 , and taking the cube root, i.e., $f^{-1}(x) = \sqrt[3]{-(x-4)} = \sqrt[3]{4-x}$

75. $A = d^2/2$ **76.** $P = 4\sqrt{A}$

- 77.** Let x be the number of ice cream bars sold. Then $W(x) = (0.20)(0.40x+200) = 0.08x+40$.

- 78.** Let x be the number of radios manufactured. Then $P(x) = (0.80)(0.90x) = 0.72x$.

- 79.** $C = 1.08P$ expresses the total cost as a function of the purchase price; and $P = C/1.08$ is the purchase price as a function of the total cost.

80. $V(x) = x^3, S(x) = \sqrt[3]{x}$

81.

$$r = \sqrt{5.625 \times 10^{-5} - \frac{V}{500}}$$

where $0 \leq V \leq 0.028125$

- 82.** Solving for I in $E = 0.4I + 10,000$, we

obtain $\frac{E-10,000}{0.4} = I$ or equivalently

$$I = \frac{5}{2}E - 25,000.$$

If $E = I$, then $I = 0.4I + 10,000$ or $0.6I = 10,000$. Thus, if $E = I$ then $I = \frac{10,000}{0.6}$ or $I = \$16,666.67$.

- 83.** When $V = \$18,000$, the depreciation rate is

$$1 - \left(\frac{18,000}{50,000}\right)^{1/5} \approx 0.1848$$

or the depreciation rate is 18.48%.

Solving for V , we obtain

$$\begin{aligned} \left(\frac{V}{50,000}\right)^{1/5} &= 1 - r \\ \frac{V}{50,000} &= (1 - r)^5 \\ V &= 50,000(1 - r)^5. \end{aligned}$$

- 84.** When $P = \$23,580$, the annual growth rate is

$$\left(\frac{23,580}{10,000}\right)^{1/10} - 1 \approx 0.0896$$

or the annual growth rate is 8.96%.

Solving for P , we obtain

$$\begin{aligned} \left(\frac{P}{10,000}\right)^{1/10} &= r + 1 \\ \frac{P}{10,000} &= (r + 1)^{10} \\ P &= 10,000(r + 1)^{10}. \end{aligned}$$

- 85.** Since $g^{-1}(x) = \frac{x+5}{3}$ and $f^{-1}(x) = \frac{x-1}{2}$, we have

$$g^{-1} \circ f^{-1}(x) = \frac{\frac{x-1}{2} + 5}{3} = \frac{x+9}{6}.$$

Likewise, since $(f \circ g)(x) = 6x - 9$, we get

$$(f \circ g)^{-1}(x) = \frac{x+9}{6}.$$

Hence, $(f \circ g)^{-1} = g^{-1} \circ f^{-1}$.

86. Since $(f \circ g \circ g^{-1} \circ f^{-1})(x) = (f \circ (g \circ g^{-1}))(f^{-1}(x)) = f(f^{-1}(x)) = x$ and the range of one function is the domain of the other function, we have $(f \circ g)^{-1} = g^{-1} \circ f^{-1}$.
87. $x^2 + (y - 1)^2 = 9$
88. $\left(\frac{\pi/3 + \pi/2}{2}, \frac{1+1}{2}\right) = \left(\frac{5\pi/6}{2}, 1\right) = \left(\frac{5\pi}{12}, 1\right)$
89. function
90. reflection
91. Domain $(-\infty, \infty)$, range $[1, \infty)$
92. Since $x - 2 \geq 0$, the domain $[2, \infty)$.
Note, the range of $-\sqrt{x}$ is $(-\infty, 0]$. Then the range of $y = -\sqrt{x-2} + 3$ is $(-\infty, 3]$.
93. Note, if $a > b > 0$ and $n > 0$, then

$$\frac{a}{n} + \frac{b}{n+1} > \frac{b}{n} + \frac{a}{n+1}.$$

Thus, the arrangement with the largest sum is

$$\frac{2025}{1} + \frac{2024}{2} + \dots + \frac{2}{2024} + \frac{1}{2025}.$$

94. If $f(x) = mx + b$, then

$$(f \circ f \circ f)(x) = m^3x + b(m^2 + m + 1).$$

Since

$$(f \circ f \circ f)(x) = 27x + 26$$

we obtain $m^3 = 27$ or $m = 3$.

Also, $b(m^2 + m + 1) = 26$. If we substitute $m = 3$, then $13b = 26$ or $m = 2$.

Thus, $f(x) = 3x + 2$. The y -intercept is $(0, 2)$.

P.4 Pop Quiz

1. $A = \pi r^2 = \pi(d/2)^2$ or $A = \frac{\pi d^2}{4}$
2. $y = 3(4x - 5) - 1 = 12x - 16$
3. $(f \circ g)(5) = f(3) = 9$
4. $M = g \circ h \circ f$
5. Interchange x and y then solve for y .

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

6. Interchange x and y then solve for y .

$$\begin{aligned} \sqrt[3]{y+1} - 4 &= x \\ y + 1 &= (x+4)^3 \\ y &= (x+4)^3 - 1 \\ g^{-1}(x) &= (x+4)^3 - 1 \end{aligned}$$

Chapter P Review Exercises

1. $\sqrt{49 \cdot 2} = 7\sqrt{2}$
2. $\sqrt{100 \cdot 2} = 10\sqrt{2}$
3. $\frac{3}{\sqrt{5}} \cdot \frac{\sqrt{5}}{\sqrt{5}} = \frac{3\sqrt{5}}{5}$
4. $\frac{4}{\sqrt{13}} \cdot \frac{\sqrt{13}}{\sqrt{13}} = \frac{4\sqrt{13}}{13}$
5. $\frac{\sqrt{5}}{\sqrt{6}} \cdot \frac{\sqrt{6}}{\sqrt{6}} = \frac{\sqrt{30}}{6}$
6. $\frac{\sqrt{3}}{2\sqrt{2}} \cdot \frac{\sqrt{2}}{\sqrt{2}} = \frac{\sqrt{6}}{4}$
7. $\frac{8}{\sqrt{2}} \cdot \frac{\sqrt{2}}{\sqrt{2}} = \frac{8\sqrt{2}}{2} = 4\sqrt{2}$
8. $\frac{9}{\sqrt{3}} \cdot \frac{\sqrt{3}}{\sqrt{3}} = \frac{9\sqrt{3}}{3} = 3\sqrt{3}$

9. The distance is $\sqrt{(-3-2)^2 + (5-(-6))^2} = \sqrt{(-5)^2 + 11^2} = \sqrt{25 + 121} = \sqrt{146}$.

The midpoint is $\left(\frac{-3+2}{2}, \frac{5-6}{2}\right) = \left(-\frac{1}{2}, -\frac{1}{2}\right)$.

10. The distance is

$\sqrt{(-1-(-2))^2 + (1-(-3))^2} = \sqrt{1^2 + 4^2} = \sqrt{17}$. The midpoint is $\left(\frac{-1-2}{2}, \frac{1-3}{2}\right) = \left(-\frac{3}{2}, -1\right)$.

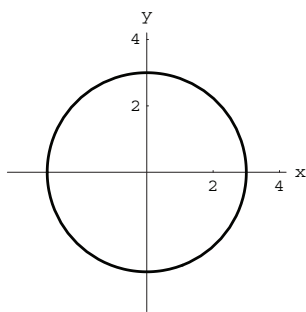
11. The distance is $\sqrt{\left(\pi - \frac{\pi}{2}\right)^2 + (1-1)^2} =$

$\sqrt{\left(\frac{\pi}{2}\right)^2 + 0} = \frac{\pi}{2}$. The midpoint is $\left(\frac{\pi/2 + \pi}{2}, \frac{1+1}{2}\right) = \left(\frac{3\pi}{4}, 1\right)$.

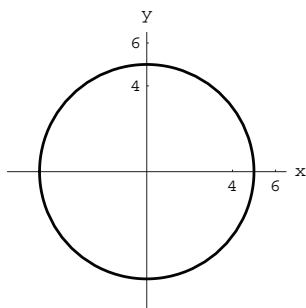
12. The distance is $\sqrt{\left(\frac{\pi}{2} - \frac{\pi}{3}\right)^2 + (2-2)^2} =$

$\sqrt{\left(\frac{\pi}{6}\right)^2 + 0} = \frac{\pi}{6}$. The midpoint is $\left(\frac{\pi/2 + \pi/3}{2}, \frac{2+2}{2}\right) = \left(\frac{5\pi}{12}, 2\right)$.

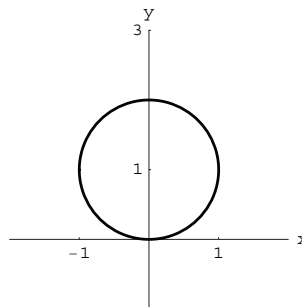
13. Circle with center at $(0, 0)$ and radius 3



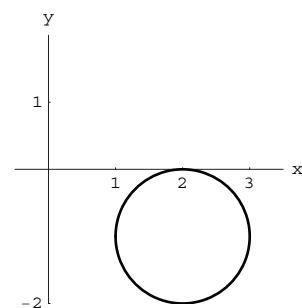
14. Circle with center at $(0, 0)$ and radius 5



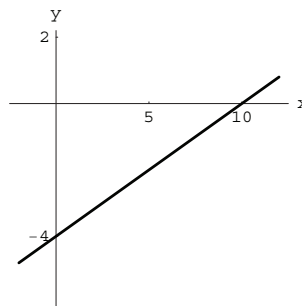
15. Circle with center at $(0, 1)$ and radius 1



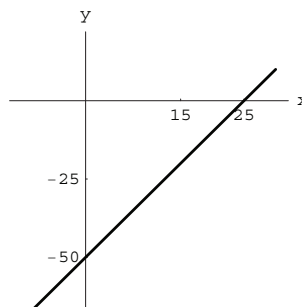
16. Circle with center at $(2, -1)$ and radius 1



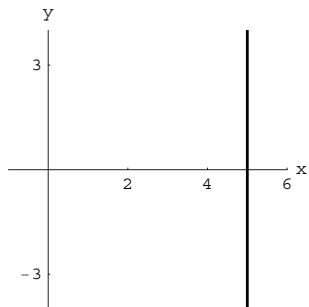
17. The line through the points $(10, 0)$ and $(0, -4)$.



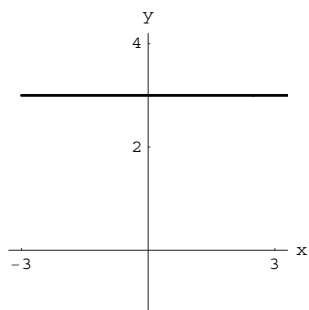
18. The line through the points $(25, 0)$ and $(0, -50)$.



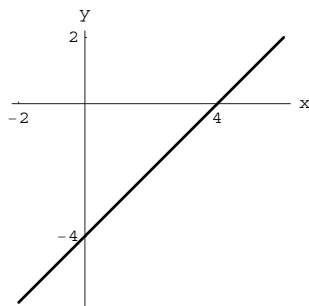
19. The vertical line through the point $(5, 0)$.



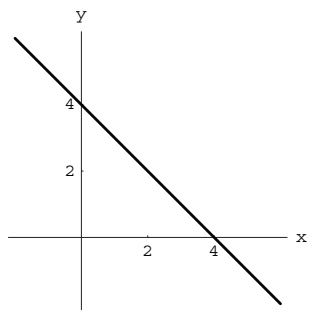
20. The horizontal line through the point $(0, 3)$.



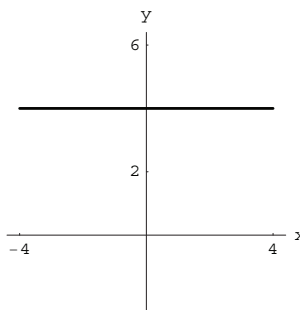
21. Domain $(-\infty, \infty)$ and range $(-\infty, \infty)$



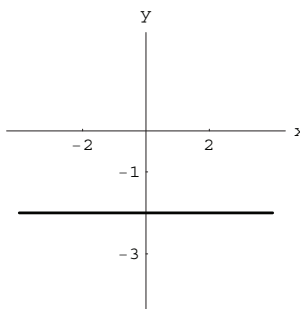
22. Domain $(-\infty, \infty)$ and range $(-\infty, \infty)$



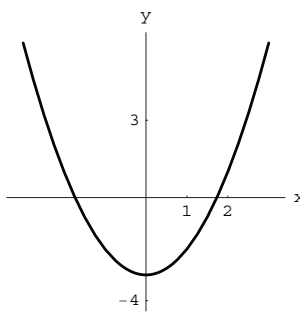
23. Domain $(-\infty, \infty)$ and range $\{4\}$. The horizontal line through the point $(0, 4)$.



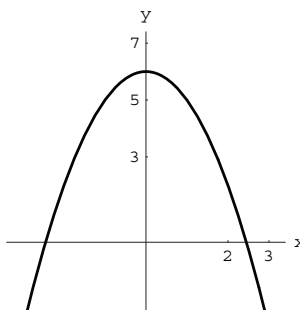
24. Domain $(-\infty, \infty)$ and range $\{-2\}$



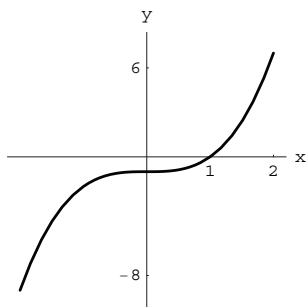
25. Domain $(-\infty, \infty)$ and range $[-3, \infty)$



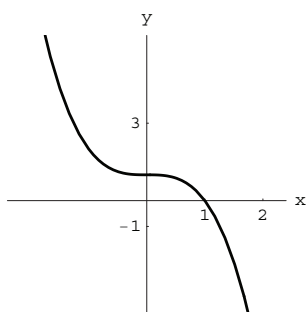
26. Domain $(-\infty, \infty)$ and range $(-\infty, 6]$



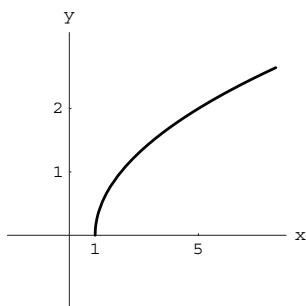
27. Domain $(-\infty, \infty)$ and range $(-\infty, \infty)$



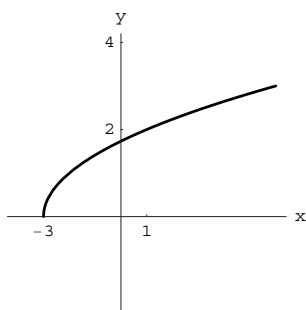
28. Domain $(-\infty, \infty)$ and range $(-\infty, \infty)$



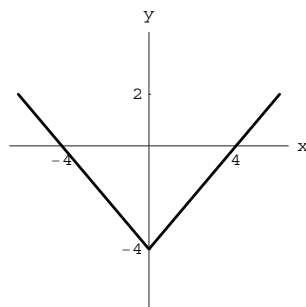
29. Domain $[1, \infty)$ and range $[0, \infty)$



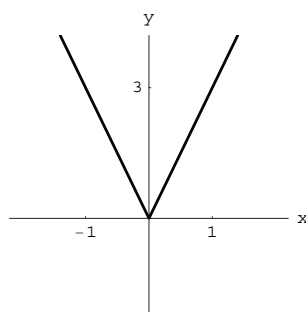
30. Domain $[-3, \infty)$ and range $[0, \infty)$



31. Domain $(-\infty, \infty)$ and range $[-4, \infty)$



32. Domain $(-\infty, \infty)$ and range $[0, \infty)$



33. $9 + 3 = 12$ 34. $6 - 7 = -1$

35. $24 - 7 = 17$ 36. $1 + 3 = 4$

37. $g(12) = 17$ 38. $f(-1) = 4$

39. $f(-3) = 12$ 40. $g(7) = 7$

41.

$$\begin{aligned} f(g(x)) &= f(2x - 7) \\ &= (2x - 7)^2 + 3 \\ &= 4x^2 - 28x + 52 \end{aligned}$$

42.

$$\begin{aligned} g(f(x)) &= g(x^2 + 3) \\ &= 2(x^2 + 3) - 7 \\ &= 2x^2 - 1 \end{aligned}$$

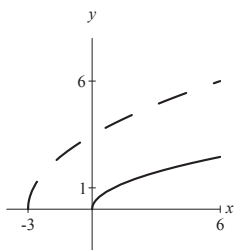
43. $g\left(\frac{x+7}{2}\right) = (x+7) - 7 = x$

44. $f(\sqrt{x-3}) = (x-3) + 3 = x$

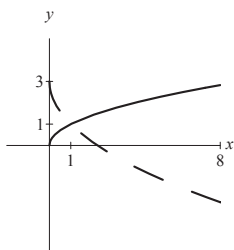
45. $g^{-1}(x) = \frac{x+7}{2}$

46. From No. 45, $g^{-1}(-3) = \frac{-3+7}{2} = 2$

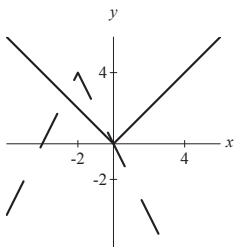
47. $f(x) = \sqrt{x}$, $g(x) = 2\sqrt{x+3}$; left by 3, stretch by 2



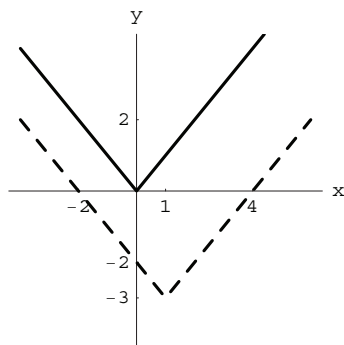
48. $f(x) = \sqrt{x}$, $g(x) = -2\sqrt{x} + 3$; stretch by 2, reflect about x -axis, up by 3



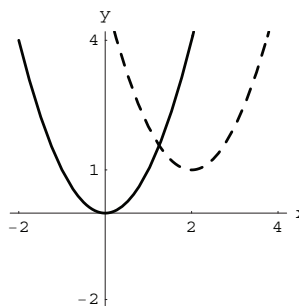
49. $f(x) = |x|$, $g(x) = -2|x+2| + 4$; left by 2, stretch by 2, reflect about x -axis, up by 4



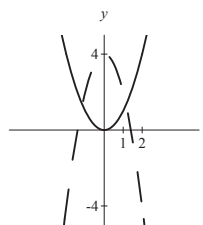
50. $f(x) = |x|$, $g(x) = |x-1| - 3$; right by 1 and down by 3



51. $f(x) = x^2$, $g(x) = (x-2)^2 + 1$; right by 2 and up by 1



52. $f(x) = x^2$, $g(x) = -2x^2 + 4$; stretch by 2, reflect about x -axis, up by 4



53. $N = h \circ j$ 54. $P = j \circ h$

55. $R = h \circ g$ 56. $Q = g \circ h$

57. $F = f \circ g$ 58. $G = g \circ f$

59. $H = f \circ g \circ j$ 60. $M = j \circ h \circ g$

61. $y = |x| - 3$, domain is $(-\infty, \infty)$, range is $[-3, \infty)$

62. $y = |x-3| - 1$, domain is $(-\infty, \infty)$, range is $[-1, \infty)$

63. $y = -2|x| + 4$, domain is $(-\infty, \infty)$, range is $(-\infty, 4]$

64. $y = -\frac{1}{2}|x| + 2$, domain is $(-\infty, \infty)$, range is $(-\infty, 2]$

65. $y = |x+2| + 1$, domain is $(-\infty, \infty)$, range is $[1, \infty)$

66. $y = -|x+1| - 2$, domain $(-\infty, \infty)$, range $(-\infty, -2]$

67. Symmetry: y -axis 68. Symmetry: y -axis

69. Symmetric about the origin

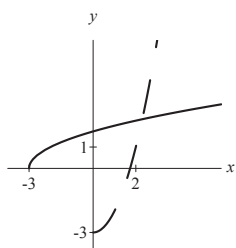
70. Symmetric about the origin

71. Neither symmetry 72. Neither symmetry

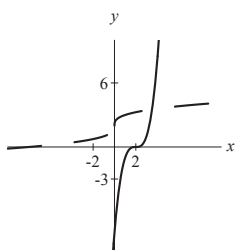
73. Symmetric about the y -axis

74. Symmetric about the y -axis

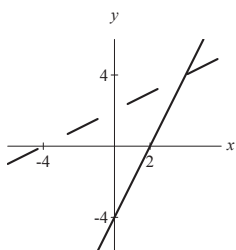
75. inverse functions,
 $f(x) = \sqrt{x+3}, g(x) = x^2 - 3$ for $x \geq 0$



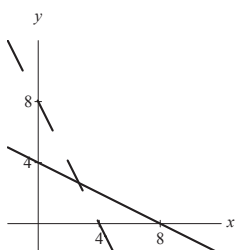
76. inverse functions,
 $f(x) = (x-2)^3, g(x) = \sqrt[3]{x} + 2$



77. inverse functions,
 $f(x) = 2x - 4, g(x) = \frac{1}{2}x + 2$



78. inverse functions,
 $f(x) = -\frac{1}{2}x + 4, g(x) = -2x + 8$



79. $f^{-1}(x) = \frac{x}{5}$ 80. $f^{-1}(x) = x - 9$

81. $f^{-1}(x) = \frac{x+21}{3}$ or $f^{-1}(x) = \frac{1}{3}x + 7$

82. $f^{-1}(x) = \frac{x+5}{2}$ or $f^{-1}(x) = \frac{1}{2}x + \frac{5}{2}$

83. $f^{-1}(x) = \sqrt[3]{x+1}$

84. $f^{-1}(x) = x^3 - 5$

85. $f^{-1}(x) = \frac{1}{x} + 3$

86. $f^{-1}(x) = \frac{1}{x-5}$

87. $f^{-1}(x) = \sqrt{x}$

88. $f^{-1}(x) = x^2 + 3$ where $x \geq 0$

89. $\sqrt{(\sqrt{5})^2 + 2^2} = \sqrt{9} = 3$

90. $\sqrt{3^2 - 1^2} = \sqrt{8} = 2\sqrt{2}$

91. From $3x - 4(0) = 9$, we get that the x -intercept is $(3, 0)$. From $3(0) - 4y = 9$, we find that the y -intercept is $(0, -\frac{9}{4})$.

92. From $0 = 2x - 3$, we get that the x -intercept is $(\frac{3}{2}, 0)$. From $y = 2(0) - 3$, we find that the y -intercept is $(0, -3)$.

93. $(x+3)^2 + (y-5)^2 = 3$

94. The center is $(3, -1)$ and the radius is 4.

95. Since $C = 2\pi r$, we get $r = \frac{C}{2\pi}$.

96. Since $A = \pi \left(\frac{d}{2}\right)^2$, we get $4A = \pi d^2$.

Then $d = \sqrt{\frac{4A}{\pi}}$ or $d = 2\sqrt{\frac{A}{\pi}}$.

97. No, since the product of the numbers from 1 through 9 is

$$1 \cdot 2 \cdot 3 \cdots 9 = 362,880$$

$$\text{and } 71^3 = 357911.$$

98. The fourth point of the parallelogram is either $Q(15, a-30)$ or $R(25, a+30)$. Suppose the two unknown points are $P(20, a)$ and $Q(15, a-30)$. The line through the origin and point Q is

$$\frac{a-30}{15}x - y = 0.$$

We apply a known formula. The shortest distance between point (x_0, y_0) and a line $Ax + By + C = 0$ is

$$d = \frac{|Ax_0 + By_0 + C|}{\sqrt{A^2 + B^2}}.$$

Then the shortest distance h between $(5, 30)$ and the line through the origin and Q is

$$h = \frac{|\frac{a-30}{15}(5) - 30|}{\sqrt{(\frac{a-30}{15})^2 + 1}} = \frac{|\frac{a-120}{3}|}{\sqrt{(\frac{a-30}{15})^2 + 1}}.$$

The distance b between the origin and Q is

$$b = \sqrt{15^2 + (a-30)^2}.$$

The area of a parallelogram is the product of the base b and height h . Since the area is 580, we obtain through some cancelations that

$$\sqrt{15^2 + (a-30)^2} \frac{|\frac{a-120}{3}|}{\sqrt{(\frac{a-30}{15})^2 + 1}} = 580$$

$$15 \left| \frac{a-120}{3} \right| = 580$$

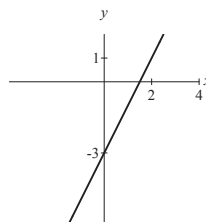
$$|a-120| = 116.$$

Hence, $a = 4$ or $a = 236$.

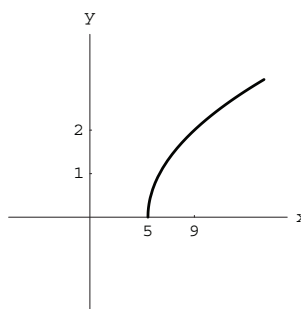
If the fourth point is $R(25, a+30)$, we still find $a = 4$ or $a = 236$. There are four parallelograms but only two values of a .

Chapter P Test

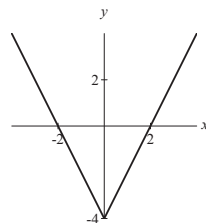
1. Domain $(-\infty, \infty)$, range $[0, \infty)$
2. Domain $[9, \infty)$, range $[0, \infty)$
3. Domain $(-\infty, \infty)$, range $(-\infty, 2]$
4. The graph of $y = 2x - 3$ includes the points $(3/2, 0), (0, -3)$



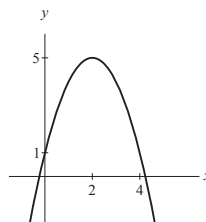
5. The graph of $f(x) = \sqrt{x-5}$ goes through $(5, 0), (9, 2)$.



6. The graph of $y = 2|x| - 4$ includes the points $(0, -4), (\pm 3, 2)$



7. The graph of $y = -(x-2)^2 + 5$ is a parabola with vertex $(2, 5)$



8. $\sqrt{9} = 3$
9. $3(2) - 1 = 5$

10. $f(5) = \sqrt{7}$

11. $g^{-1}(x) = \frac{x+1}{3}$ or $g^{-1}(x) = \frac{1}{3}x + \frac{1}{3}$

12. Using the answer from Exercise 11,

we find $g^{-1}(20) = \frac{20+1}{3} = 7$.

13. $\sqrt{72} = 6\sqrt{2}$

14. $\frac{\sqrt{25}}{\sqrt{6}} = \frac{5\sqrt{6}}{6}$

15. $\frac{20}{2\sqrt{2}} = 5\sqrt{2}$

16. $\left(\frac{3+(-3)}{2}, \frac{5+6}{2}\right) = \left(0, \frac{11}{2}\right)$

17. $\sqrt{(-2-3)^2 + (4-(-1))^2} = \sqrt{25+25} = 5\sqrt{2}$.

18. $(x+4)^2 + (y-1)^2 = 7$

19. Center $(4, -1)$, radius $\sqrt{6}$

20. Solving $3a - 9 = 6$, we obtain $a = 5$.

21. Symmetric about the y -axis

since $f(-x) = f(x)$

22. Interchange x and y then solve for y .

$$\begin{aligned} x &= 3 + \sqrt[3]{y-2} \\ x-3 &= \sqrt[3]{y-2} \\ (x-3)^3 &= y-2 \\ (x-3)^3 + 2 &= y \end{aligned}$$

The inverse is $g^{-1}(x) = (x-3)^3 + 2$.

23. Since $A = \left(\frac{p}{4}\right)^2$, we get $A = \frac{p^2}{16}$.