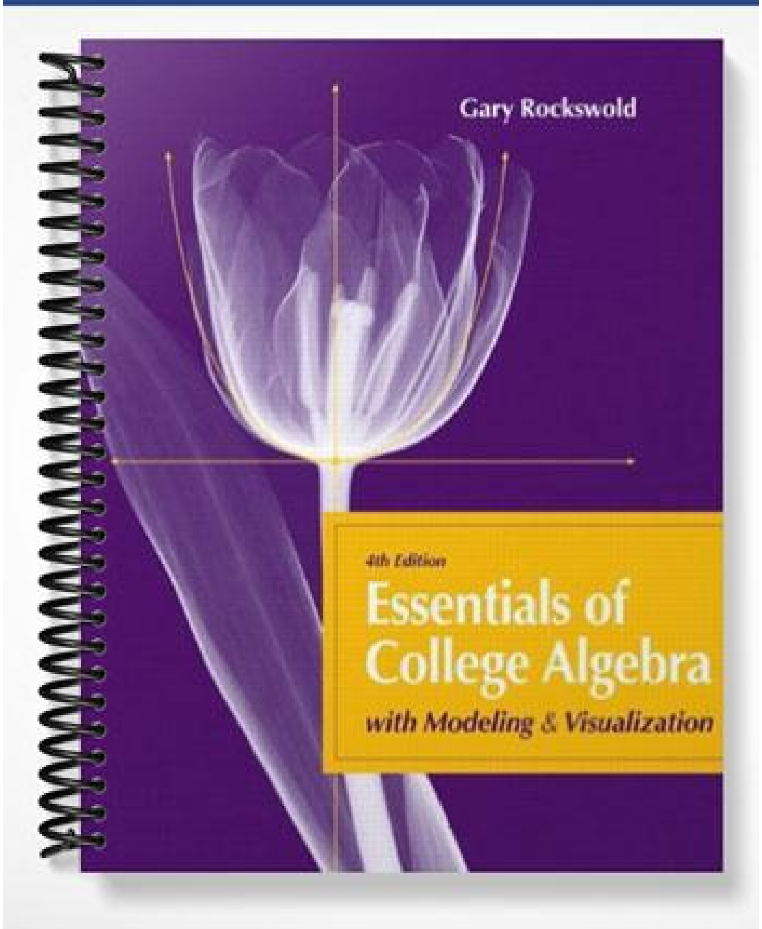
# SOLUTIONS MANUAL



# Chapter 2: Linear Functions and Equations

## 2.1: Linear Functions and Models

1. (a) $V(t) = -0.2t + 12.8 \Rightarrow V(0) = -0.2(0) + 12.8 = 12.8,\ V(4) = -0.2(4) + 12.8 = 12.0$

   (b) $V(t) = -0.2t + 12.8 \Rightarrow V(2) = -0.2(2) + 12.8 = 12.4$ million vehicles, estimate involves interpolation;

   $V(6) = -0.2(6) + 12.8 = 11.6$, estimate involves extrapolation.

   (c) The interpolation is more accurate.

2. (a) $A(t) = 13.5t + 237 \Rightarrow A(0) = 13.5(0) + 237 = 237,\ A(2) = 13.5(2) + 237 = 264$

   (b) $A(t) = 13.5t + 237 \Rightarrow A(-2) = 13.5(-2) + 237 = \$210$ billion, estimate involves extrapolation;

   $A(1) = 13.5(1) + 237 = \$250.5$ billion, estimate involves interpolation.

   (c) The interpolation is more accurate.

3. Evaluating $f$ for $x = 1, 2, 3, 4$ we get: $f(1) = 5(1) - 2 = 3$, value agrees with table;

   $f(2) = 5(2) - 2 = 8$, value agrees with table; $f(3) = 5(3) - 2 = 13$, value agrees with table;

   $f(4) = 5(4) - 2 = 18$, value agrees with table. Since all agree, $f$ models the data exactly.

4. Evaluating $f$ for $x = 5, 10, 15, 20$ we get: $f(5) = 1 - 0.2(5) = 0$, value agrees with table;

   $f(10) = 1 - 0.2(10) = -1$, value agrees with table; $f(15) = 1 - 0.2(15) = -2$, value agrees with table;

   $f(20) = 1 - 0.2(20) = -3$, value does not agree with table. Since $f(20)$ does not agree (but is close) and the others agree, $f$ models the data approximately.

5. Evaluating $f$ for $x = -6, 0, 1$ we get: $f(-6) = 3.7 - 1.5(-6) = 12.7$, value agrees with table;

   $f(0) = 3.7 - 1.5(0) = 3.7$, value agrees with table; $f(1) = 3.7 - 1.5(1) = 2.2$, value does not agree with table. Since $f(1)$ does not agree (but is close) and the others agree, $f$ models the data approximately.

6. Evaluating $f$ for $x = 1, 2, 5$ we get: $f(1) = 13.3(1) - 6.1 = 7.2$, value agrees with table;

   $f(2) = 13.3(2) - 6.1 = 20.5$; value agrees with table. $f(5) = 13.3(5) - 6.1 = 60.4$, value agrees with table.

   Since all agree, $f$ models the data exactly.

7. slope $= \dfrac{\text{rise}}{\text{run}} = \dfrac{-1}{2} = -\dfrac{1}{2}$; $y$-intercept: 3 $\Rightarrow y = mx + b \Rightarrow y = -\dfrac{1}{2}x + 3 \Rightarrow f(x) = -\dfrac{1}{2}x + 3$

8. slope $= \dfrac{\text{rise}}{\text{run}} = \dfrac{4}{6} = \dfrac{2}{3}$; $y$-intercept: –1 $\Rightarrow y = mx + b \Rightarrow y = \dfrac{2}{3}x - 1 \Rightarrow f(x) = \dfrac{2}{3}x - 1$

9. slope $= \dfrac{\text{rise}}{\text{run}} = \dfrac{2}{1} = 2$; $y = mx + b \Rightarrow y = 2x + b$

   Use $(1, 7)$ to find $b$: $7 = 2(1) + b \Rightarrow b = 5 \Rightarrow y = 2x + 5 \Rightarrow f(x) = 2x + 5$

10. slope $= \dfrac{\text{rise}}{\text{run}} = \dfrac{-10}{15} = -\dfrac{2}{3}$; $y = mx + b \Rightarrow y = -\dfrac{2}{3}x + b$

    Use $(15, 40)$ to find $b$: $40 = -\dfrac{2}{3}(15) + b \Rightarrow b = 50 \Rightarrow y = -\dfrac{2}{3}x + 50 \Rightarrow f(x) = -\dfrac{2}{3}x + 50$

11. (a) $f(x) = \frac{x}{16}$
    (b) $f(x) = 10x$
    (c) $f(x) = 0.06x + 6.50$
    (d) $f(x) = 500$
12. (a) $f(x) = 50x$ (miles)
    (b) $f(x) = 24$
    (c) $f(x) = 6x + 1$
    (d) The radius of the tire is 1 ft., so the distance traveled by the tire after 1 rotation is $2\pi r = 2\pi$ ft. If the tire rotates 14 times per second, the speed of the car is $f(x) = 28\pi$ feet per second.
13. (a) Slope $= \frac{\text{rise}}{\text{run}} = \frac{2}{1} = 2$; $y$-intercept: –1; $x$-intercept: 0.5
    (b) $f(x) = ax + b \Rightarrow f(x) = 2x - 1$
    (c) 0.5
    (d) increasing
14. (a) Slope $= \frac{\text{rise}}{\text{run}} = \frac{-2}{1} = -2$; $y$-intercept: 1; $x$-intercept: 0.5
    (b) $f(x) = ax + b \Rightarrow f(x) = -2x + 1$
    (c) 0.5
    (d) decreasing
15. (a) Slope $= \frac{\text{rise}}{\text{run}} = \frac{-1}{3} = -\frac{1}{3}$; $y$-intercept: 2; $x$-intercept: 6
    (b) $f(x) = ax + b \Rightarrow f(x) = -\frac{1}{3}x + 2$
    (c) 6
    (d) decreasing
16. (a) Slope $= \frac{\text{rise}}{\text{run}} = \frac{3}{4}$; $y$-intercept: –3; $x$-intercept: 4
    (b) $f(x) = ax + b \Rightarrow f(x) = \frac{3}{4}x - 3$
    (c) 4
    (d) increasing
17. (a) Slope $= \frac{\text{rise}}{\text{run}} = \frac{100}{5} = 20$; $y$-intercept: –50; $x$-intercept: 2.5
    (b) $f(x) = ax + b \Rightarrow f(x) = 20x - 50$
    (c) 2.5
    (d) increasing
18. (a) Slope $= \frac{\text{rise}}{\text{run}} = \frac{-200}{1} = -200$; $y$-intercept: 300; $x$-intercept: 1.5
    (b) $f(x) = ax + b \Rightarrow f(x) = -200x + 300$
    (c) 1.5
    (d) decreasing

19. $f(x) = 3x + 2$; $m = 3$; $y$-intercept $= 2$. See Figure 19.

20. $f(x) = -\frac{3}{2}x$; $m = -\frac{3}{2}$; $y$-intercept $= 0$. See Figure 20.

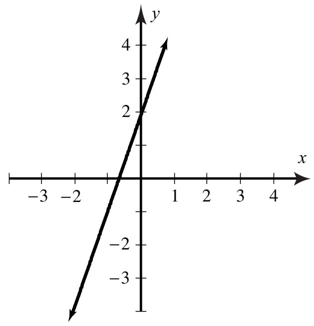



Figure 19

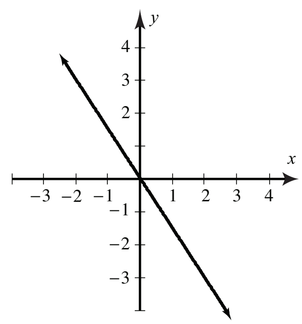



Figure 20

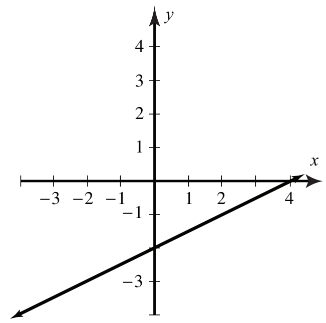



Figure 21

21. $f(x) = \frac{1}{2}x - 2$; $m = \frac{1}{2}$; $y$-intercept $= -2$. See Figure 21.

22. $f(x) = 3 - x$; $m = -1$; $y$-intercept $= 3$. See Figure 22.

23. $g(x) = -2$; $m = 0$; $y$-intercept $= -2$. See Figure 23.

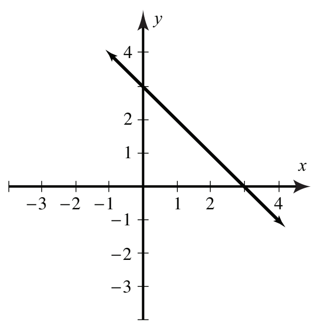



Figure 22

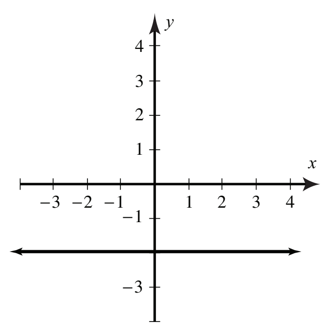



Figure 23

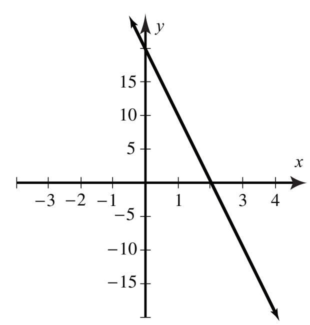



Figure 24

24. $g(x) = 20 - 10x$; $m = -10$; $y$-intercept $= 20$. See Figure 24.

25. $f(x) = 4 - \frac{1}{2}x$; Slope $= -\frac{1}{2}$; $y$-intercept $= 4$. See Figure 25.

26. $f(x) = 2x - 3$; Slope $= 2$; $y$-intercept $= -3$. See Figure 26.

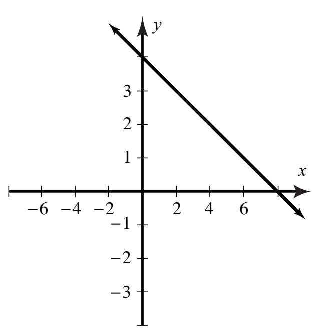



Figure 25

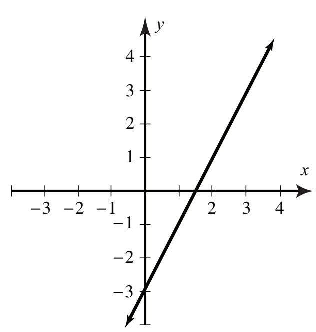



Figure 26

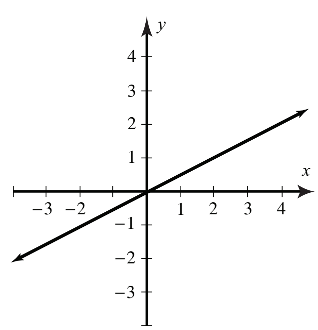



Figure 27

27. $g(x) = \frac{1}{2}x$; Slope $= \frac{1}{2}$; $y$-intercept $= 0$. See Figure 27.

28. $g(x) = 3$; Slope $= 0$; $y$-intercept $= 3$. See Figure 28.

29. $g(x) = 5 - 5x$; Slope $= -5$; $y$-intercept $= 5$. See Figiure 29.

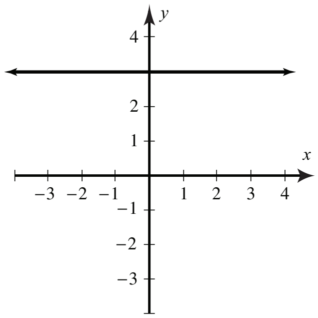


Figure 28

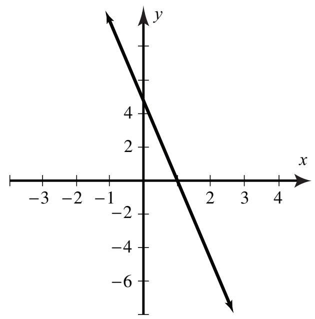


Figure 29

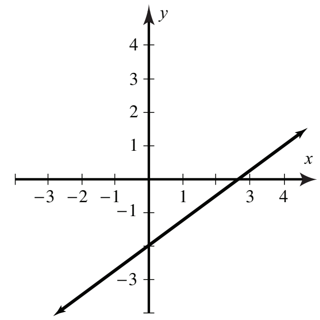


Figure 30

30. $g(x) = \frac{3}{4}x - 2$; Slope $= \frac{3}{4}$; $y$-intercept $= -2$. See Figure 30.

31. $f(x) = 20x - 10$; Slope $= 20$; $y$-intercept $= -10$. See Figure 31.

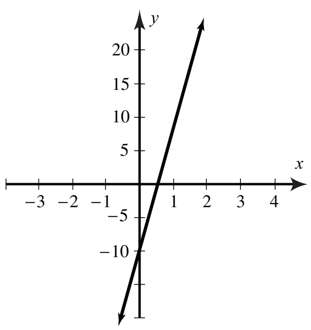


Figure 31

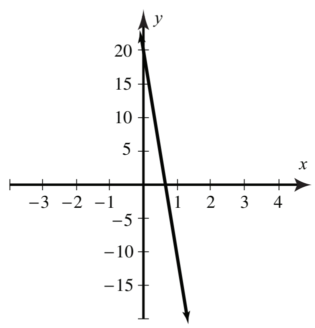


Figure 32

32. $g(x) = -30x + 20$; Slope $= -30$; $y$-intercept $= 20$. See Figure 32.

33. $f(x) = ax + b \Rightarrow f(x) = -\frac{3}{4}x + \frac{1}{3}$

34. $f(x) = ax + b \Rightarrow f(x) = -122x + 805$

35. $f(x) = ax + b \Rightarrow f(x) = 15x + 0$, or $f(x) = 15x$

36. $f(x) = ax + b \Rightarrow f(x) = 1.68x + 1.23$

37. Since the slope $= 0.5 = \frac{0.5}{1} = \frac{-0.5}{-1}$, to go from (1, 4.5) to another point on the line, you can move 0.5 unit down and 1 unit to the left. This gives the point $(1 - 1, 4.5 - 0.5) = (0, 4)$, so the $y$-intercept is 4.

$f(x) = mx + b \Rightarrow f(x) = 0.5x + 4$

38. Since the slope $= -2 = \frac{-2}{1} = \frac{2}{-1}$, to go from (–1, 5) to another point on the line, you can move 2 units down and 1 unit to the right. This gives the point $(-1 + 1, 5 - 2) = (0, 3)$, so the $y$-intercept is 3.

$f(x) = mx + b \Rightarrow f(x) = -2x + 3$

39. $f(-2) = 10$ and $f(2) = 10 \Rightarrow$ we have points $(-2, 10)$ and $(2, 10)$; the slope of this line is $m = \dfrac{10 - 10}{2 - (-2)} = \dfrac{0}{4} = 0$. The average rate of change is 0. For two distinct real numbers $a$ and $b$ the points are $(a, 10)$ and $(b, 10)$; the slope of this line is $m = \dfrac{10 - 10}{b - a} = \dfrac{0}{b - a} = 0$. The average rate of change is 0.

40. $f(-2) = -5$ and $f(2) = -5 \Rightarrow$ we have points $(-2, -5)$ and $(2, -5)$; the slope of this line is $m = \dfrac{(-5) - (-5)}{2 - (-2)} = \dfrac{0}{4} = 0$. The average rate of change is 0. For two distinct real numbers $a$ and $b$ the points are $(a, -5)$ and $(b, -5)$; the slope of this line is $m = \dfrac{-5 - (-5)}{b - a} = \dfrac{0}{b - a} = 0$. The average rate of change is 0.

41. $f(-2) = -\dfrac{1}{4}(-2) = \dfrac{1}{2}$ and $f(2) = -\dfrac{1}{4}(2) = -\dfrac{1}{2} \Rightarrow$ we have points $\left(-2, \dfrac{1}{2}\right)$ and $\left(2, -\dfrac{1}{2}\right)$; the slope of this line is $m = \dfrac{-\frac{1}{2} - \frac{1}{2}}{2 - (-2)} = \dfrac{-1}{4} = -\dfrac{1}{4}$. The average rate of change is $-\dfrac{1}{4}$. For two distinct real numbers $a$ and $b$ the points are given by $f(b) = -\dfrac{1}{4}b$ or $\left(a, -\dfrac{1}{4}a\right)$ and $\left(b, -\dfrac{1}{4}b\right)$; the slope of this line is $m = \dfrac{-\frac{1}{4}b - \left(-\frac{1}{4}a\right)}{b - a} = \dfrac{-\frac{1}{4}(b - a)}{b - a} = -\dfrac{1}{4}$. The average rate of change is $-\dfrac{1}{4}$.

42. $f(-2) = \dfrac{5}{3}(-2) = -\dfrac{10}{3}$ and $f(2) = \dfrac{5}{3}(2) = \dfrac{10}{3} \Rightarrow$ we have points $\left(-2, -\dfrac{10}{3}\right)$ and $\left(2, \dfrac{10}{3}\right)$; the slope of this line is $m = \dfrac{\frac{10}{3} - \left(-\frac{10}{3}\right)}{2 - (-2)} = \dfrac{\frac{20}{3}}{4} = \dfrac{5}{3}$. The average rate of change is $\dfrac{5}{3}$. For two distinct real numbers $a$ and $b$ the points are given by $f(a) = \dfrac{5}{3}a$ and $f(b) = \dfrac{5}{3}b$ or $\left(a, \dfrac{5}{3}a\right)$ and $\left(b, \dfrac{5}{3}b\right)$; the slope of this line is $m = \dfrac{\frac{5}{3}b - \frac{5}{3}a}{b - a} = \dfrac{\frac{5}{3}(b - a)}{b - a} = \dfrac{\frac{5}{3}}{1} = \dfrac{5}{3}$. The average rate of change is $\dfrac{5}{3}$.

43. $f(-2) = 4 - 3(-2) = 4 + 6 = 10$ and $f(2) = 4 - 3(2) = 4 - 6 = -2 \Rightarrow$ we have points $(-2, 10)$ and $(2, -2)$; the slope of this line is $m = \dfrac{-2 - 10}{2 - (-2)} = \dfrac{-12}{4} = -3$. The average rate of change is $-3$. For two distinct real numbers $a$ and $b$ the points are given by $f(a) = 4 - 3a$ and $f(b) = 4 - 3b$ or $(a, 4 - 3a)$ and $(b, 4 - 3b)$; the slope of this line is $m = \dfrac{(4 - 3b) - (4 - 3a)}{b - a} = \dfrac{-3b + 3a}{b - a} = \dfrac{-3(b - a)}{b - a} = \dfrac{-3}{1} = -3$. The average rate of change is $-3$.

44. $f(-2) = 5(-2) + 1 = -9$ and $f(2) = 5(2) + 1 = 11 \Rightarrow$ we have points $(-2, -9)$ and $(2, 11)$; the slope of this line is $m = \dfrac{11 - (-9)}{2 - (-2)} = \dfrac{20}{4} = 5$. The average rate of change is 5. For two distinct real numbers $a$ and $b$ the points are given by $f(a) = 5a + 1$ and $f(b) = 5b + 1$ or $(a, 5a + 1)$ and $(b, 5b + 1)$; the slope of this line is $m = \dfrac{(5b + 1) - (5a + 1)}{b - a} = \dfrac{5b - 5a}{b - a} = \dfrac{5(b - a)}{b - a} = \dfrac{5}{1} = 5$. The average rate of change is 5.

45. The height of the Empire State Building is constant; the graph that has no rate of change is d.

46. The price of a car in 1980 is above \$0 and then climbs through 2000; the graph that has positive $y$ and positive slope is b.

47. As time increases the distance to the finish line decreases; the graph that shows this decline in distance as time increases is c.

48. Working zero hours merits \$0 pay and as time increases, pay increases; the graph that represents this is a.

49. $I(t) = 1.5t + 68$; $t$ represents years after 2006; $D = \{t \mid 0 \leq t \leq 4\}$.

50. $C(t) = 20t + 208$; $t$ represents years after 2005; $D = \{t \mid 0 \leq t \leq 3\}$.

51. $V(t) = 32t$; $t$ represents time in seconds; $D = \{t \mid 0 \leq t \leq 3\}$

52. $S(t) = 30 - \frac{3}{2}t$; $t$ represents time in seconds; $D = \{t \mid 0 \leq t \leq 20\}$

53. $P(t) = 21.5 + 0.581t$; $t$ represents years after 1900; $D = \{t \mid 0 \leq t \leq 100\}$

54. $I(t) = 8.3 - 0.32t$; $t$ represents years after 1992; $D = \{t \mid 0 \leq t \leq 9\}$

55. (a) $W(t) = -10t + 300$

(b) $W(7) = -10(7) + 300 = 230$ gallons

(c) See Figure 55. $x$-intercept: 30, after 30 minutes the tank is empty; $y$-intercept: 300, the tank initially contains 300 gallons of water.

(d) $D = \{t \mid 0 \leq t \leq 30\}$

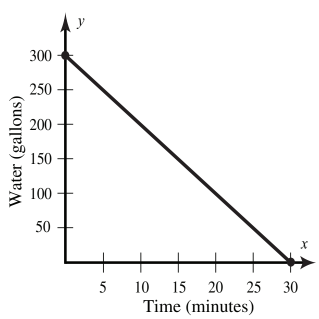


Figure 55

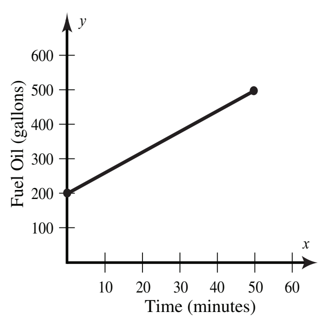


Figure 56

56. (a) $f(x) = 6x + 200$

(b) See Figure 56. $D = \{x \mid 0 \leq x \leq 50\}$

(c) The $y$-intercept is 200, which indicates that the tank initially contains 200 gallons of fuel oil.

(d) No, the $x$-intercept of $-\frac{100}{3}$ is not in the domain.

57. (a) $f(x) = 4.3x + 40$

(b) Since 2006 corresponds to $x = 0$, 2012 corresponds to $x = 6$; $f(6) = 4.3(6) + 40 = 65.8$, which means that about 65,800,000 may be infected by 2012.

58. (a) $f(x) = 16.7 - 0.21x$

(b) Since 1990 corresponds to $x = 0$, 2003 corresponds to $x = 13$; $f(13) = 16.7 - 0.21(13) = 13.97$, which means that in 2003 there were about 13.97 births per 1000 people in the United States. This value is close to the actual value of 14.

59. (a) $f(x) = 0.25x + 0.5$

(b) $f(2.5) = 0.25(2.5) + 0.5 = 1.125$ inches

60. (a) $V = \pi r^2 h = \pi(240)^2(1) = 57{,}600\pi \approx 180{,}956$ cubic inches

(b) $g(x) = (180{,}956 \text{ cu. in.})\left(\dfrac{1 \text{ gal.}}{231 \text{ cu. in.}}\right)x = \dfrac{180{,}956}{231}x$, where $x$ is the number of hours.

(c) $g(2.5) = \dfrac{180{,}956}{231}(2.5) \approx 1958$ gallons

(d) No; 1958 gallons in 2.5 hours means 783.2 gallons of water land on the roof in 1 hour. Since $\dfrac{783.2}{400} = 1.958$, there should be 2 drain spouts.

61. (a) $(5, 84), (10, 169) \Rightarrow$ slope $= \dfrac{169 - 84}{10 - 5} = 17$

$(10, 169), (15, 255) \Rightarrow$ slope $= \dfrac{255 - 169}{15 - 10} = 17.2$

$(15, 255), (20, 338) \Rightarrow$ slope $= \dfrac{338 - 255}{20 - 15} = 16.6$

(b) $f(x) = 17x$

(c) See Figure 61. The slope indicates that the number of miles traveled per gallon is 17.

(d) $f(30) = 17(30) = 510$ miles. This indicates that the vehicle traveled 510 miles on 30 gallons of gasoline.

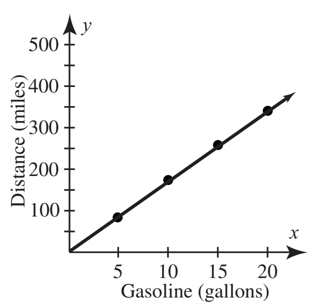



Figure 61

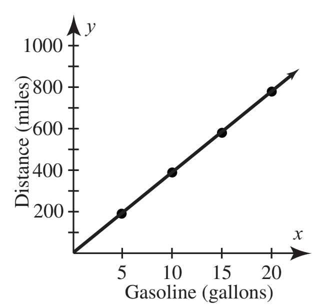



Figure 62

62. (a) $(5, 194), (10, 392) \Rightarrow$ slope $= \dfrac{392 - 194}{10 - 5} = 39.6$

$(10, 392), (15, 580) \Rightarrow$ slope $= \dfrac{580 - 392}{15 - 10} = 37.6$

$(15, 580), (20, 781) \Rightarrow$ slope $= \dfrac{781 - 580}{20 - 15} = 40.2$

(b) $f(x) = 39x$

(c) See Figure 62. The slope indicates that the number of miles traveled per gallon is 39.

(d) $f(30) = 39(30) = 1170$ miles. This indicates that the vehicle traveled 1170 miles on 30 gallons of gasoline.

63. (a) The maximum speed limit is 55 mph and the minimum is 30 mph.

(b) The speed limit is 55 for $0 \le x < 4$, $8 \le x < 12$, and $16 \le x < 20$. This is $4 + 4 + 4 = 12$ miles.

(c) $f(4) = 40$, $f(12) = 30$, and $f(18) = 55$.

(d) The graph is discontinuous when $x = 4, 6, 8, 12,$ and $16$. The speed limit changes at each discontinuity.

64. (a) The initial amount in the cash machine occurred when $x = 0$ and was \$1000. The final amount occurred when $x = 60$ and was \$600.

(b) Using the graph, $f(10) = 900$ and $f(50) = 600$. $f$ is not continuous.

(c) Since the amount of money in the machine decreased 3 times, there were 3 withdrawals.

(d) The largest withdrawal of \$300 occurred after 15 minutes.

(e) The amount deposited was \$200.

65. (a) $P(1.5) = 0.97$; it costs \$0.97 to mail 1.5 ounces. $P(3) = 1.14$; it costs \$1.14 to mail 3 ounces.

(b) See Figure 65. $D = \{x \mid 0 < x \le 5\}$

(c) $x = 1, 2, 3, 4$

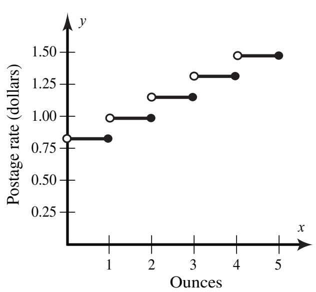



Figure 65

66. (a) The initial amount in the pool occurs when $x = 0$. Since $f(0) = 50$, the initial amount is 50,000 gallons. The final amount of water in the pool occurs when $x = 5$. Since, $f(5) = 30$, the final amount is 30,000 gallons.

(b) The water level remained constant during the first day and the fourth day, when $0 \le x \le 1$ or $3 \le x \le 4$.

(c) $f(2) = 45$ thousand and $f(4) = 40$ thousand

(d) During the second and third days, the amount of water changed from 50,000 gallons to 40,000 gallons. This represents 10,000 gallons in 2 days or 5000 gallons per day were being pumped out of the pool.

67. (a) $f(1.5) = 30$; $f(4) = 10$

(b) $m_1 = 20$ indicates that the car is moving away from home at 20 mph; $m_2 = -30$ indicates that the car is moving toward home at 30 mph; $m_3 = 0$ indicates that the car is not moving; $m_4 = -10$ indicates that the car is moving toward home at 10 mph.

(c) The driver starts at home and drives away from home at 20 mph for 2 hours. The driver then travels toward home at 30 mph for 1 hour. Then the car does not move for 1 hour. Finally, the driver returns home in 1 hour at 10 mph.

(d) Increasing: $0 \le x \le 2$; Decreasing: $2 \le x \le 3$ or $4 \le x \le 5$; Constant: $3 \le x \le 4$

68. (a) $f(1.5) = 50$; $f(4) = 100$

(b) $m_1 = -75$ indicates that the car is moving toward home at 75 mph; $m_2 = 0$ indicates that the car is not moving; $m_3 = 50$ indicates that the car is moving away from home at 50 mph.

(c) The driver starts 125 miles from home and drives toward home at 75 mph for 1 hour. Then the car does not move for 2 hours. Finally, the driver travels away from home at 50 mph for 1 hour.

(d) Increasing: $3 \le x \le 4$; Decreasing: $0 \le x \le 1$; Constant: $1 \le x \le 3$

69. (a) $D = \{x \mid -5 \le x \le 5\}$

(b) $f(-2) = 2, f(0) = 0 + 3 = 3, f(3) = 3 + 3 = 6$

(c) See Figure 69.

(d) $f$ is continuous.

70. (a) $D = \{x \mid -3 \le x \le 3\}$

(b) $f(-2) = 2(-2) + 1 = -3, f(0) = 0 - 1 = -1, f(3) = 3 - 1 = 2$

(c) See Figure 70.

(d) $f$ is not continuous.

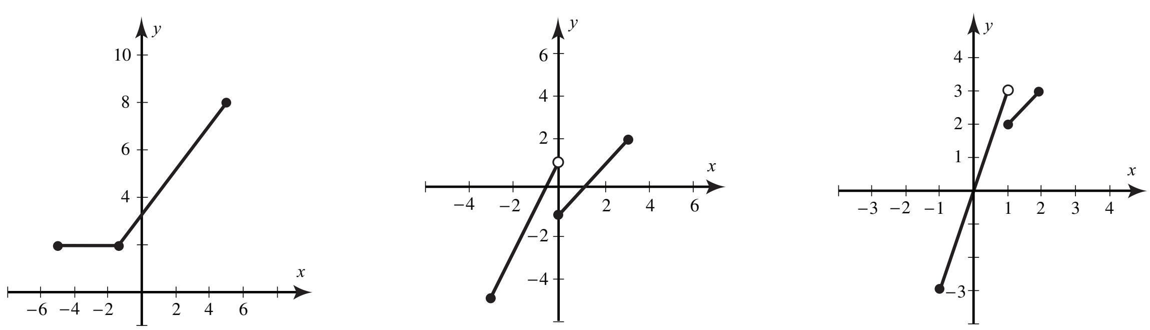


Figure 69 Figure 70 Figure 71

71. (a) $D = \{x \mid -1 \le x \le 2\}$

(b) $f(-2)$ is undefined, $f(0) = 3(0) = 0, f(3)$ is undefined

(c) See Figure 71.

(d) $f$ is not continuous.

72. (a) $D = \{x \mid -6 \le x \le 4\}$

(b) $f(-2) = 0, f(0) = 3(0) = 0, f(3) = 3(3) = 9$

(c) See Figure 72.

(d) $f$ is not continuous.

73. (a) $D = \{x \mid -3 \le x \le 3\}$

(b) $f(-2) = -2, f(0) = 1, f(3) = 2 - 3 = -1$

(c) See Figure 73.

(d) $f$ is not continuous.

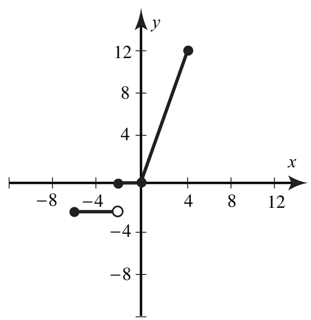


Figure 72

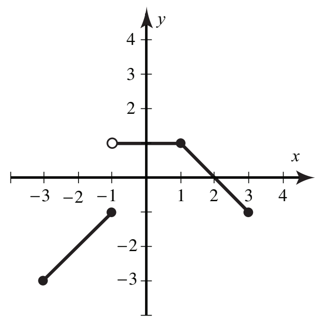


Figure 73

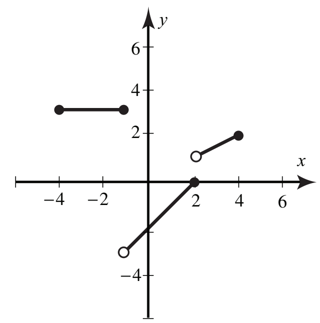


Figure 74

74. (a) $D = \{x \mid -4 \le x \le 4\}$

(b) $f(-2) = 3, f(0) = 0 - 2 = -2, f(3) = 0.5(3) = 1.5$

(c) See Figure 74.

(d) $f$ is not continuous.

75. $f(-4) = -\frac{1}{2}(-4) + 1 = 3, (-4, 3);$ $f(-2) = -\frac{1}{2}(-2) + 1 = 2, (-2, 2);$ graph a segment from $(-4, 3)$ to $(-2, 2)$, use a closed dot for each point. See Figure 75.

$f(-2) = 1 - 2(-2) = 5, (-2, 5);$ $f(1) = 1 - 2(1) = -1, (1, -1);$ graph a segment from $(-2, 5)$ to $(1, -1)$, use an open dot at $(-2, 5)$ and a closed dot for $(1, -1)$. See Figure 75.

$f(1) = \frac{2}{3}(1) + \frac{4}{3} = 2, (1, 2);$ $f(4) = \frac{2}{3}(4) + \frac{4}{3} = 4, (4, 4);$ graph a segment from $(1, 2)$ to $(4, 4)$, use an open dot at $(1, 2)$ and a closed dot for $(4, 4)$. See Figure 75.

76. $f(-3) = \frac{3}{2} - \frac{1}{2}(-3) = 3, (-3, 3);$ $f(-1) = \frac{3}{2} - \frac{1}{2}(-1) = 2, (-1, 2);$ graph a segment from $(-3, 3)$ to $(-1, 2)$, use a closed dot at $(-3, 3)$ and an open dot at $(-1, 2)$. See Figure 76.

$f(-1) = -2(-1) = 2, (-1, 2);$ $f(2) = -2(2) = -4, (2, -4);$ graph a segment from $(-1, 2)$ to $(2, -4)$, use a closed dot at each point. See Figure 76.

$f(2) = \frac{1}{2}(2) - 5 = -4, (2, -4);$ $f(3) = \frac{1}{2}(3) - 5 = -\frac{7}{2}, \left(3, -\frac{7}{2}\right);$ graph a segment from $(2, -4)$ to $\left(3, -\frac{7}{2}\right)$, use an open dot at $(2, -4)$ and a closed dot for $\left(3, -\frac{7}{2}\right)$. See Figure 76.

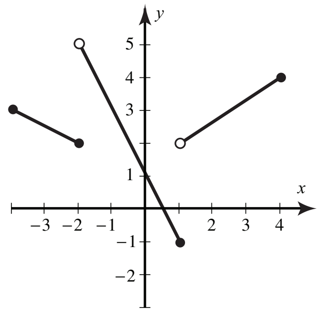


Figure 75

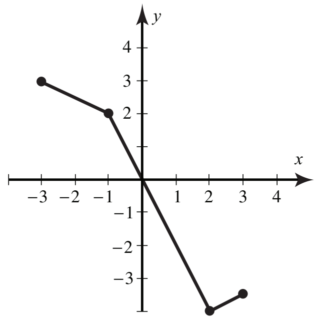


Figure 76

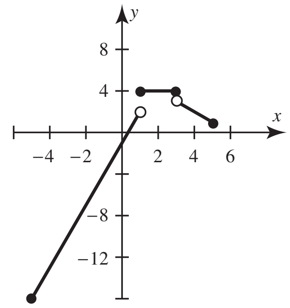


Figure 77

77. (a) $f(-3) = 3(-3) - 1 = -10$, $f(1) = 4$, $f(2) = 4$, and $f(5) = 6 - 5 = 1$

(b) The function $f$ is constant with a value of 4 on the interval [1, 3].

(c) See Figure 77. $f$ is not continuous.

78. (a) $g(-8) = -2(-8) - 6 = 10$; $g(-2) = -2(-2) - 6 = -2$; $g(2) = 0.5(2) + 1 = 2$;

$g(8) = 0.5(8) + 1 = 5$

(b) The slope is equal to 1 for $-2 < x < 2$ and 0.5 for $2 \le x \le 8$. That is, $g$ is increasing for $-2 < x \le 8$.

(c) See Figure 78. $g$ is continuous.

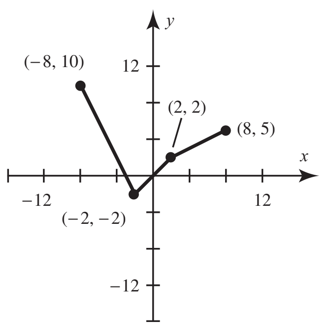



Figure 78

79. (a) Graph $Y_1 = \text{int}(2X - 1)$ as shown in Figure 79.

(b) $f(-3.1) = \llbracket 2(-3.1) - 1 \rrbracket = \llbracket -7.2 \rrbracket = -8$ and $f(1.7) = \llbracket 2(1.7) - 1 \rrbracket = \llbracket 2.4 \rrbracket = 2$

80. (a) Graph $Y_1 = \text{int}(X + 1)$ as shown in Figure 80.

(b) $f(-3.1) = \llbracket -3.1 + 1 \rrbracket = \llbracket -2.1 \rrbracket = -3$ and $f(1.7) = \llbracket 1.7 + 1 \rrbracket = \llbracket 2.7 \rrbracket = 2$

[–10, 10, 1] by [–10, 10, 1]

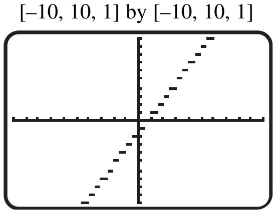


Figure 79

[–10, 10, 1] by [–10, 10, 1]

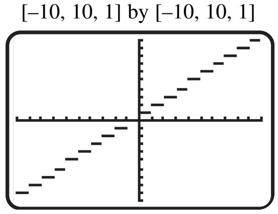


Figure 80

[–10, 10, 1] by [–10, 10, 1]

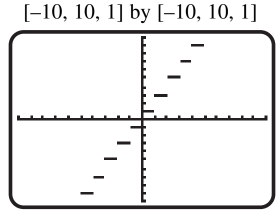


Figure 81

81. (a) Graph $Y_1 = 2(\text{int}(X)) + 1$ as shown in Figure 81.

(b) $f(-3.1) = 2\llbracket -3.1 \rrbracket + 1 = 2(-4) + 1 = -7$ and $f(1.7) = 2\llbracket 1.7 \rrbracket + 1 = 2(1) + 1 = 3$

82. (a) Graph $Y_1 = \text{int}(-X)$ as shown in Figure 82.

(b) $f(-3.1) = [\![-(-3.1)]\!] = [\![3.1]\!] = 3$ and $f(1.7) = [\![-1.7]\!] = -2$

83. (a) $f(x) = 0.8\left[\!\!\left[\dfrac{x}{2}\right]\!\!\right]$ for $6 \le x \le 18$

(b) Graph $Y_1 = 0.8(\text{int}(X/2))$ as shown in Figure 83.

(c) $f(8.5) = 0.8\left[\!\!\left[\dfrac{8.5}{2}\right]\!\!\right] = 0.8[\![4.25]\!] = 0.8(4) = \$3.20$; $f(15.2) = 0.8\left[\!\!\left[\dfrac{15.2}{2}\right]\!\!\right] = 0.8[\![7.6]\!] = 0.8(7) = \$5.60$

[–10, 10, 1] by [–10, 10, 1]

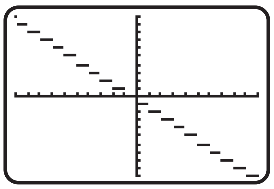


Figure 82

[6, 18, 1] by [0, 8, 1]

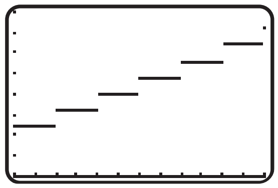


Figure 83

[–3, 4, 1] by [–3, 3, 1]

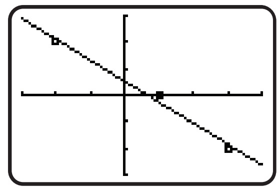


Figure 85

[–2, 3, 1] by [–2, 7, 1]

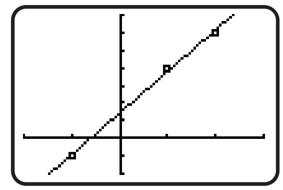


Figure 86

84. (a) Total cost $= \$36/\text{ft}(9 \text{ ft}) = \$324$

(b) $P(x) = 36[\![x]\!]$

85. Enter the $x$-values into the list $L_1$ and the $y$-values into the list $L_2$. Use the statistical feature of your graphing calculator to find the correlation coefficient $r$ and the regression equation. $r \approx -0.993$; $y \approx -0.789x + 0.526$ See Figure 85.

86. Enter the $x$-values into the list $L_1$ and the $y$-values into the list $L_2$. Use the statistical feature of your graphing calculator to find the correlation coefficient $r$ and the regression equation. $r \approx 0.999$; $y \approx 2.357x + 1.429$ See Figure 86.

87. (a) Enter the $x$-values into the list $L_1$ and the $y$-values into the list $L_2$ in the statistical feature of your graphing calculator; the scatterplot of the data indicates that the correlation coefficient will be positive (and very close to 1).

(b) $y = ax + b$, where $a \approx 3.25$ and $b \approx -2.45$; $r \approx 0.9994$

(c) $y \approx 3.25(2.4) - 2.45 = 5.35$

88. (a) Enter the $x$-values into the list $L_1$ and the $y$-values into the list $L_2$ in the statistical feature of your graphing calculator; the scatterplot of the data indicates that the correlation coefficient will be positive (and close to 1).

(b) $y = ax + b$, where $a = 0.985$ and $b = 5.02$; $r \approx 0.9967$

(c) $y \approx 0.985(2.4) + 5.02 = 7.384$

89. (a) Enter the $x$-values into the list $L_1$ and the $y$-values into the list $L_2$ in the statistical feature of your graphing calculator; the scatterplot of the data indicates that the correlation coefficient will be negative (and very close to –1).

(b) $y = ax + b$, where $a \approx -3.8857$ and $b \approx 9.3254$; $r \approx -0.9996$

(c) $y \approx -3.8857(2.4) + 9.3254 = -0.00028$. *Due to rounding answers may very slightly.*

90. (a) Enter the $x$-values into the list $L_1$ and the $y$-values into the list $L_2$ in the statistical feature of your graphing calculator; the scatterplot of the data indicates that the correlation coefficient will be negative (and very close to –1).

(b) $y = ax + b$, where $a \approx -2.9867$ and $b = 24.92$; $r \approx -0.9995$

(c) $y \approx -2.9867(2.4) + 24.92 \approx 17.752$

91. (a) The data points (50, 990), (650, 9300), (950, 15000) and (1700, 25000) are plotted in Figure 91. The data appears to have a linear relationship.

(b) Use the linear regression feature on your graphing calculator to find the values of $a$ and $b$ in the equation $y = ax + b$. In this instance, $a \approx 14.680$ and $b \approx 277.82$.

(c) We must find the $x$-value when $y = 37{,}000$. This can be done by solving the equation $37{,}000 = 14.680x + 277.82 \Rightarrow 14.680x = 36{,}722.18 \Rightarrow x \approx 2500$ light years away. One could also solve the equation graphically to obtain the same approximation.

[–100, 1800, 100] by [–1000, 28000, 1000]

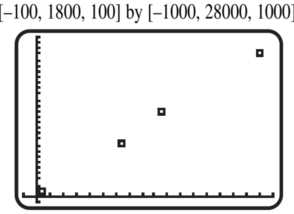


Figure 91

[–10, 110, 10] by [0, 5, 1]

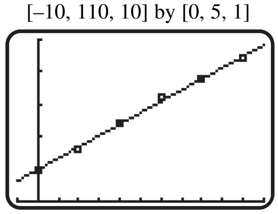


Figure 92

[–5, 40, 5] by [0, 6, 1]

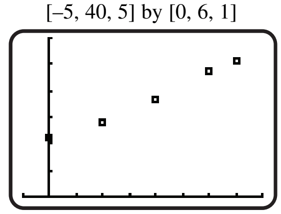


Figure 93a

[–5, 40, 5] by [0, 6, 1]

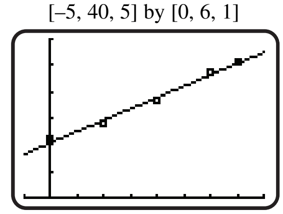


Figure 93c

92. (a) Use the linear regression feature on your graphing calculator to find the values of $a$ and $b$ in the equation $y = ax + b$. In this instance, $a \approx 0.0349$ and $b \approx 0.9905$. See Figure 92.

(b) If $P = 50$, then $D \approx 0.0349(50) + 0.9905 \approx 2.74$ minutes.

93. (a) Positive. See Figure 93a.

(b) Enter the $x$-values into the list $L_1$ and the $y$-values into the list $L_2$ in the statistical feature of your graphing calculator. $f(x) \approx 0.0854x + 2.078$

(c) See Figure 93c. The slope indicates the number of miles traveled by passengers per year.

(d) Year 2010 $\Rightarrow x = 40$; $f(40) \approx 0.0854(40) + 2.078 \approx 5.5$; 5.5 trillion miles

94. (a) Enter the $x$-values into the list $L_1$ and the $y$-values into the list $L_2$ in the statistical feature of your graphing calculator. $f(x) \approx 0.233x + 13.552$

(b) See Figure 94. The slope indicates the increase in the number of high school students enrolled per year.

(c) Year 2002 $\Rightarrow x = 2$; $f(2) \approx 0.233(2) + 13.552 = 14.018$ million. The result is slightly lower than the actual 14.1 million.

[–100, 1800, 100] by [–1000, 28,000, 1000]

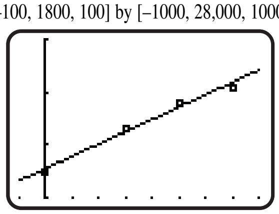


Figure 94

## Extended and Discovery Exercises for Section 2.1

1. *Answers may vary.*

2. (a) Graph $Y_1 = 4X - X^\wedge 3$. If one repeatedly zooms in on any portion of the graph, it begins to look like a straight line. See Figure 2 for an example.

   (b) A linear approximation will be a good approximation over a small interval.

[−0.625, 0.625, 0.1] by [−0.625, 0.625, 0.1]

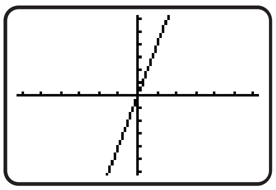


Figure 2

[1.580, 1.584, 0.001] by [−6.252, −6.248, 0.001]

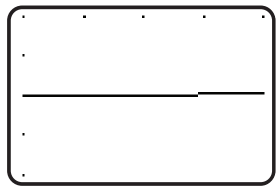


Figure 3

3. (a) Graph $Y_1 = X^\wedge 4 - 5X^\wedge 2$. If one repeatedly zooms in on any portion of the graph, it begins to look like a straight line. See Figure 3 for an example.

   (b) A linear approximation will be a good approximation over a small interval.

## 2.2: Equations of Lines

1. Find slope: $m = \dfrac{-2 - 2}{3 - 1} = \dfrac{-4}{2} = -2$. Using $(x_1, y_1) = (1, 2)$ and point-slope form $y = m(x - x_1) + y_1$, we get $y = -2(x - 1) + 2$. See Figure 1.

2. Find slope: $m = \dfrac{0 - 3}{1 - (-2)} = \dfrac{-3}{3} = -1$. Using $(x_1, y_1) = (-2, 3)$ and point-slope form $y = m(x - x_1) + y_1$, we get $y = -(x + 2) + 3$. See Figure 2.

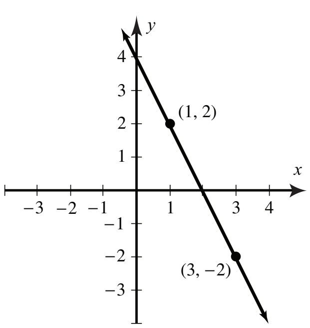



Figure 1

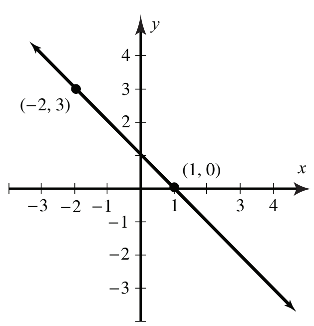



Figure 2

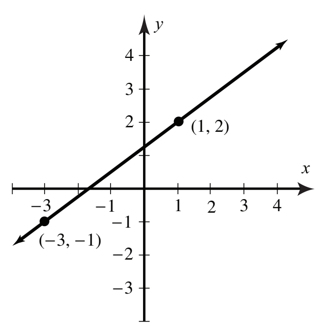



Figure 3

3. Find slope: $m = \dfrac{2 - (-1)}{1 - (-3)} = \dfrac{3}{4}$. Using $(x_1, y_1) = (-3, -1)$ and point-slope form $y = m(x - x_1) + y_1$, we get $y = \dfrac{3}{4}(x + 3) - 1$. See Figure 3.

4. Find slope: $m = \frac{(-3) - 2}{(-2) - (-1)} = \frac{-5}{-1} = 5$. Using $(x_1, y_1) = (-1, 2)$ and point-slope form $y = m(x - x_1) + y_1$, we get $y = 5(x + 1) + 2$. See Figure 4.

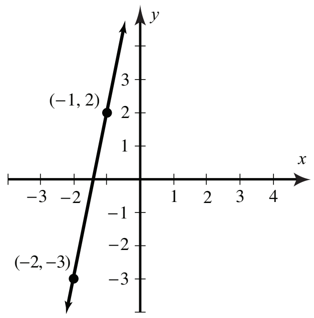



Figure 4

5. The point-slope form is given by $y = m(x - x_1) + y_1$. Thus, $m = -2.4$ and $(x_1, y_1) = (4, 5) \Rightarrow$ $y = -2.4(x - 4) + 5 \Rightarrow y = -2.4x + 9.6 + 5 \Rightarrow y = -2.4x + 14.6$.

6. The point-slope form is given by $y = m(x - x_1) + y_1$. Thus, $m = 1.7$ and $(x_1, y_1) = (-8, 10) \Rightarrow$ $y = 1.7(x + 8) + 10 \Rightarrow y = 1.7x + 13.6 + 10 \Rightarrow y = 1.7x + 23.6$.

7. First find the slope between the points (1, –2) and (–9, 3): $m = \frac{3 - (-2)}{-9 - 1} = -\frac{1}{2}$.

$y = -\frac{1}{2}(x - 1) - 2 \Rightarrow y = -\frac{1}{2}x + \frac{1}{2} - 2 \Rightarrow y = -\frac{1}{2}x - \frac{3}{2}$.

8. $m = \frac{-12 - 10}{5 - (-6)} = -\frac{22}{11} = -2$; thus, $y = -2(x + 6) + 10 \Rightarrow y = -2x - 12 + 10 \Rightarrow$ $y = -2x - 2$.

9. $(4, 0), (0, -3)$; $m = \frac{-3 - 0}{0 - 4} = \frac{3}{4}$. Thus, $y = \frac{3}{4}(x - 4) + 0$ or $y = \frac{3}{4}x - 3$.

10. $(-2, 0), (0, 5)$; $m = \frac{5 - 0}{0 - (-2)} = \frac{5}{2}$. Thus, $y = \frac{5}{2}(x + 2) + 0$ or $y = \frac{5}{2}x + 5$.

11. Using the points (0, –1) and (3, 1), we get $m = \frac{1 - (-1)}{3 - 0} = \frac{2}{3}$ and $b = -1$; $y = mx + b \Rightarrow y = \frac{2}{3}x - 1$.

12. Using the points (0, 50) and (100, 0),

we get $m = \frac{0 - 50}{100 - 0} = \frac{-50}{100} = -\frac{1}{2}$ and $b = 50$; $y = mx + b \Rightarrow y = -\frac{1}{2}x + 50$.

13. Using the points (–2, 1.8) and (1, 0), we get $m = \frac{0 - 1.8}{1 - (-2)} = \frac{-1.8}{3} = -\frac{18}{30} = -\frac{3}{5}$; to find $b$, we use (1, 0) in $y = mx + b$ and solve for $b$: $0 = -\frac{3}{5}(1) + b \Rightarrow b = \frac{3}{5}$; $y = -\frac{3}{5}x + \frac{3}{5}$.

14. Using the points (–4, –2) and (3, 1), we get $m = \frac{1 - (-2)}{3 - (-4)} = \frac{3}{7}$; to find $b$, we use (3, 1) in $y = mx + b$ and solve for $b$: $1 = \frac{3}{7}(3) + b \Rightarrow b = -\frac{2}{7}$; $y = \frac{3}{7}x - \frac{2}{7}$.

15. c

16. f

17. b

18. a

19. e

20. d

21. $m = \dfrac{2-(-4)}{1-(-1)} = 3;\ y = 3(x+1) - 4 = 3x + 3 - 4 = 3x - 1$

22. $m = \dfrac{-3-6}{2-(-1)} = -3;\ y = -3(x+1) + 6 = -3x - 3 + 6 = -3x + 3$

23. $m = \dfrac{-3-5}{1-4} = \dfrac{8}{3};\ y = \dfrac{8}{3}(x-4) + 5 = \dfrac{8}{3}x - \dfrac{32}{3} + 5 = \dfrac{8}{3}x - \dfrac{17}{3}$

24. $m = \dfrac{-3-(-2)}{-2-8} = -\dfrac{1}{2};\ y = -\dfrac{1}{2}(x-8) - 2 = -\dfrac{1}{2}x + 4 - 2 = -\dfrac{1}{2}x + 2$

25. $b = 5$ and $m = -7.8 \Rightarrow y = -7.8x + 5.$

26. $b = -155$ and $m = 5.6 \Rightarrow y = 5.6x - 155.$

27. The line passes through the points (0, 45) and (90, 0).

$m = \dfrac{0-45}{90-0} = -\dfrac{1}{2};\ b = 45$ and $m = -\dfrac{1}{2} \Rightarrow y = -\dfrac{1}{2}x + 45$

28. The line passes through the points (−6, 0) and (0, −8).

$m = \dfrac{-8-0}{0-(-6)} = -\dfrac{4}{3};\ b = -8$ and $m = -\dfrac{4}{3} \Rightarrow y = -\dfrac{4}{3}x - 8$

29. $m = -3$ and $b = 5 \Rightarrow y = -3x + 5$

30. Using the point-slope form with

$m = \dfrac{1}{3}$ and $(x_1, y_1) = \left(\dfrac{1}{2}, -2\right)$, we get $y = \dfrac{1}{3}\left(x - \dfrac{1}{2}\right) - 2 = \dfrac{1}{3}x - \dfrac{1}{6} - 2 = \dfrac{1}{3}x - \dfrac{13}{6}.$

31. $m = \dfrac{0-(-6)}{4-0} = \dfrac{6}{4} = \dfrac{3}{2}$ and $b = -6;\ y = mx + b \Rightarrow y = \dfrac{3}{2}x - 6$

32. $m = \dfrac{\frac{7}{4} - (-\frac{1}{4})}{\frac{5}{4} - \frac{3}{4}} = \dfrac{\frac{8}{4}}{\frac{2}{4}} = 4;$ using the point-slope form with $m = 4$ and $\left(\dfrac{3}{4}, -\dfrac{1}{4}\right)$, we get

$y = 4\left(x - \dfrac{3}{4}\right) - \dfrac{1}{4} = 4x - 3 - \dfrac{1}{4} = 4x - \dfrac{13}{4}.$

33. $m = \dfrac{\frac{2}{3} - \frac{3}{4}}{\frac{1}{5} - \frac{1}{2}} = \dfrac{-\frac{1}{12}}{-\frac{3}{10}} = \dfrac{5}{18};$ using the point-slope form with $m = \dfrac{5}{18}$ and $\left(\dfrac{1}{2}, \dfrac{3}{4}\right)$, we get

$y = \dfrac{5}{18}\left(x - \dfrac{1}{2}\right) + \dfrac{3}{4} \Rightarrow y = \dfrac{5}{18}x - \dfrac{5}{36} + \dfrac{3}{4} \Rightarrow y = \dfrac{5}{18}x + \dfrac{11}{18}.$

34. $m = \dfrac{-\frac{7}{6} - \frac{5}{3}}{\frac{5}{6} - (-\frac{7}{3})} = \dfrac{-\frac{17}{6}}{\frac{19}{6}} = -\dfrac{17}{19};$ using the point-slope form with $m = -\dfrac{17}{19}$ and $\left(-\dfrac{7}{3}, \dfrac{5}{3}\right)$, we get

$y = -\dfrac{17}{19}\left(x + \dfrac{7}{3}\right) + \dfrac{5}{3} \Rightarrow y = -\dfrac{17}{19}x - \dfrac{119}{57} + \dfrac{5}{3} \Rightarrow y = -\dfrac{17}{19}x - \dfrac{24}{57} \Rightarrow y = -\dfrac{17}{19}x - \dfrac{8}{19}.$

35. The line has a slope of 4 and passes through the point (–4, –7); $y = 4(x+4) - 7 \Rightarrow y = 4x + 9.$

36. The line has a slope of $-\frac{3}{4}$ and passes through the point $(1, 3)$;

$y = -\frac{3}{4}(x - 1) + 3 \Rightarrow y = -\frac{3}{4}x + \frac{3}{4} + 3 = -\frac{3}{4}x + \frac{15}{4}$

37. The slope of the perpendicular line is equal to $\frac{3}{2}$ and the line passes through the point (1980, 10);

$y = \frac{3}{2}(x - 1980) + 10 \Rightarrow y = \frac{3}{2}x - 2960$

38. The slope of the perpendicular lineis equal to $-\frac{1}{6}$ and the line passes through the point (15, –7);

$y = -\frac{1}{6}(x - 15) - 7 \Rightarrow y = -\frac{1}{6}x - \frac{27}{6} = -\frac{1}{6}x - \frac{9}{2}$

39. $y = \frac{2}{3}x + 3 \Rightarrow m = \frac{2}{3}$; the parallel line has slope $\frac{2}{3}$; since it passes through (0, –2.1), the $y$-intercept $= -2.1$; $y = mx + b \Rightarrow y = \frac{2}{3}x - 2.1$.

40. $y = -4x - \frac{1}{4} \Rightarrow m = -4$; the parallel line has slope $-4$; since it passes through (2, –5), the equation is $y = -4(x - 2) - 5 = -4x + 8 - 5 = -4x + 3$.

41. $y = -2x \Rightarrow m = -2$; the perpendicular line has slope $\frac{1}{2}$; since it passes through (–2, 5), the equation is $y = \frac{1}{2}(x + 2) + 5 = \frac{1}{2}x + 1 + 5 = \frac{1}{2}x + 6$.

42. $y = -\frac{6}{7}x + \frac{3}{7} \Rightarrow m = -\frac{6}{7}$; the perpendicular line has slope $\frac{7}{6}$; since it passes through (3, 8), the equation is $y = \frac{7}{6}(x - 3) + 8 = \frac{7}{6}x - \frac{7}{2} + 8 = \frac{7}{6}x + \frac{9}{2}$.

43. $y = -x + 4 \Rightarrow m = -1$; the perpendicular line has slope 1; since it passes through (15, –5), the equation is $y = 1(x - 15) - 5 = x - 15 - 5 = x - 20$.

44. $y = \frac{2}{3}x + 2 \Rightarrow m = \frac{2}{3}$; the parallel line has slope $\frac{2}{3}$; since it passes through (4, –9), the equation is $y = \frac{2}{3}(x - 4) - 9 = \frac{2}{3}x - \frac{8}{3} - 9 = \frac{2}{3}x - \frac{35}{3}$.

45. $m = \frac{1 - 3}{-3 - 1} = \frac{-2}{-4} = \frac{1}{2}$; a line parallel to this line also has slope $m = \frac{1}{2}$. Using $(x_1, y_1) = (5, 7)$, $m = \frac{1}{2}$, and point-slope form $y = m(x - x_1) + y_1$, we get $y = \frac{1}{2}(x - 5) + 7 \Rightarrow$ $y = \frac{1}{2}x + \frac{9}{2}$.

46. $m = \frac{8 - 3}{2000 - 1980} = \frac{5}{20} = \frac{1}{4}$; a line parallel to this line also has slope $m = \frac{1}{4}$. Using $(x_1, y_1) = (1990, 4)$, $m = \frac{1}{4}$, and point-slope form $y = m(x - x_1) + y_1$, we get $y = \frac{1}{4}(x - 1990) + 4 \Rightarrow$ $y = \frac{1}{4}x - \frac{1990}{4} + 4 \Rightarrow y = \frac{1}{4}x - \frac{987}{2}$.

47. $m = \frac{\frac{2}{3} - \frac{1}{2}}{-3 - (-5)} = \frac{\frac{1}{6}}{2} = \frac{1}{12}$; a line perpendicular to this line has slope $m = -\frac{12}{1} = -12$. Using $(x_1, y_1) = (-2, 4)$, $m = -12$, and point-slope form $y = m(x - x_1) + y_1$, we get $y = -12(x + 2) + 4 \Rightarrow y = -12x - 24 + 4 \Rightarrow y = -12x - 20$.

48. $m = \dfrac{0-(-5)}{-4-(-3)} = \dfrac{5}{-1} = -5$. A line perpendicular to this line will have slope $m = \dfrac{1}{5}$. Using

$(x_1, y_1) = \left(\dfrac{3}{4}, \dfrac{1}{4}\right)$, $m = \dfrac{1}{5}$, and point-slope form $y = m(x - x_1) + y_1$, we get $y = \dfrac{1}{5}\left(x - \dfrac{3}{4}\right) + \dfrac{1}{4} \Rightarrow$

$y = \dfrac{1}{5}x - \dfrac{3}{20} + \dfrac{1}{4} \Rightarrow y = \dfrac{1}{5}x + \dfrac{2}{20} \Rightarrow y = \dfrac{1}{5}x + \dfrac{1}{10}$.

49. $x = -5$

50. $x = 1.95$

51. $y = 6$

52. $y = 10.7$

53. Since the line $y = 15$ is horizontal, the perpendicular line through $(4, -9)$ is vertical and has equation $x = 4$.

54. Since the line $x = 15$ is vertical, the perpendicular line through $(1.6, 7.5)$ is horizontal and has equation $y = -9.5$.

55. The line through $(19, 5.5)$ and parallel to $x = 4.5$ is also vertical and has equation $x = 19$.

56. Since the line $y = -2.5$ is horizontal, the parallel line through (1985, 67) is also horizontal with equation $y = 67$.

57. Let $4x - 5y = 20$.

$x$-intercept: Substitute $y = 0$ and solve for $x$. $4x - 5(0) = 20 \Rightarrow 4x = 20 \Rightarrow x = 5$; $x$-intercept: 5

$y$-intercept: Substitute $x = 0$ and solve for $y$. $4(0) - 5y = 20 \Rightarrow -5y = 20 \Rightarrow y = -4$; $y$-intercept: $-4$

See Figure 57.

58. Let $-3x - 5y = 15$.

$x$-intercept: Substitute $y = 0$ and solve for $x$. $-3x - 5(0) = 15 \Rightarrow -3x = 15 \Rightarrow x = -5$; $x$-intercept: $-5$

$y$-intercept: Substitute $x = 0$ and solve for $y$. $-3(0) - 5y = 15 \Rightarrow -5y = 15 \Rightarrow y = -3$; $y$-intercept: $-3$

See Figure 58.

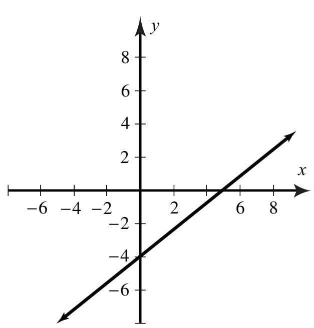


Figure 57

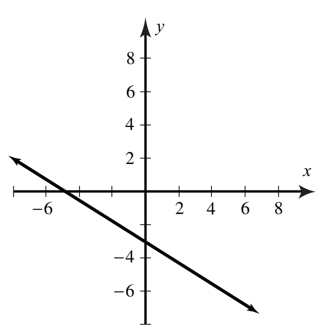


Figure 58

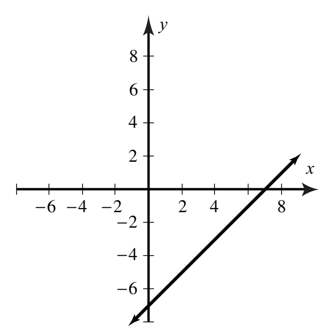


Figure 59

59. Let $x - y = 7$.

$x$-intercept: Substitute $y = 0$ and solve for $x$. $x - 0 = 7 \Rightarrow x = 7$; $x$-intercept: 7

$y$-intercept: Substitute $x = 0$ and solve for $y$. $0 - y = 7 \Rightarrow -y = 7 \Rightarrow y = -7$; $y$-intercept: $-7$

See Figure 59.

60. Let $15x - y = 30$.

$x$-intercept: Substitute $y = 0$ and solve for $x$. $15x - 0 = 30 \Rightarrow 15x = 30 \Rightarrow x = 2$; $x$-intercept: 2

$y$-intercept: Substitute $x = 0$ and solve for $y$. $15(0) - y = 30 \Rightarrow -y = 30 \Rightarrow y = -30$; $y$-intercept: $-30$

See Figure 60.

61. Let $6x - 7y = -42$.

$x$-intercept: Substitute $y = 0$ and solve for $x$. $6x - 7(0) = -42 \Rightarrow 6x = -42 \Rightarrow x = -7$; $x$-intercept: $-7$

$y$-intercept: Substitute $x = 0$ and solve for $y$. $6(0) - 7y = -42 \Rightarrow -7y = -42 \Rightarrow y = 6$; $y$-intercept: 6

See Figure 61.

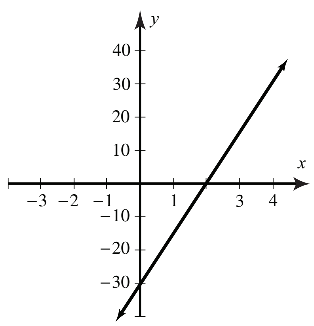


Figure 60

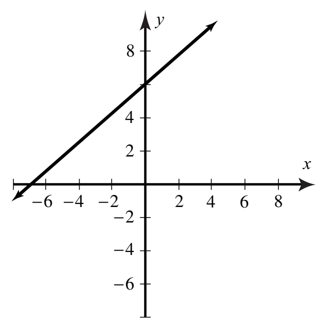


Figure 61

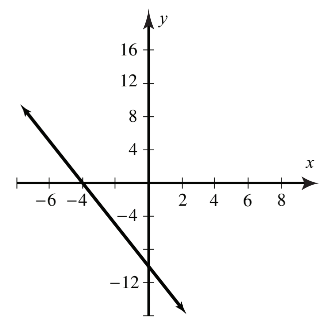


Figure 62

62. Let $5x + 2y = -20$.

$x$-intercept: Substitute $y = 0$ and solve for $x$. $5x + 2(0) = -20 \Rightarrow 5x = -20 \Rightarrow x = -4$; $x$-intercept: $-4$

$y$-intercept: Substitute $x = 0$ and solve for $y$. $5(0) + 2y = -20 \Rightarrow 2y = -20 \Rightarrow y = -10$; $y$-intercept: $-10$

See Figure 62.

63. Let $y - 3x = 7$.

$x$-intercept: Substitute $y = 0$ and solve for $x$. $0 - 3x = 7 \Rightarrow -3x = 7 \Rightarrow x = -\frac{7}{3}$; $x$-intercept: $-\frac{7}{3}$

$y$-intercept: Substitute $x = 0$ and solve for $y$. $y - 3(0) = 7 \Rightarrow y - 0 = 7 \Rightarrow y = 7$; $y$-intercept: 7

See Figure 63.

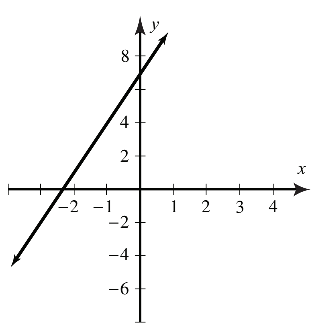


Figure 63

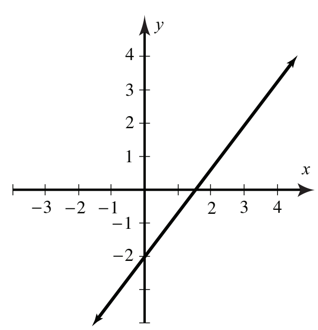


Figure 64

64. Let $4x - 3y = 6$.

$x$-intercept: Substitute $y = 0$ and solve for $x$. $4x - 3(0) = 6 \Rightarrow 4x = 6 \Rightarrow x = \frac{3}{2}$; $x$-intercept: $\frac{3}{2}$

$y$-intercept: Substitute $x = 0$ and solve for $y$. $4(0) - 3y = 6 \Rightarrow -3y = 6 \Rightarrow y = -2$; $y$-intercept: $-2$

See Figure 64.

65. Let $0.2x + 0.4y = 0.8$.

$x$-intercept: Substitute $y = 0$ and solve for $x$. $0.2x + 0.4(0) = 0.8 \Rightarrow 0.2x = 0.8 \Rightarrow x = 4$; $x$-intercept: 4

$y$-intercept: Substitute $x = 0$ and solve for $y$. $0.2(0) + 0.4y = 0.8 \Rightarrow 0.4y = 0.8 \Rightarrow y = 2$; $y$-intercept: 2

See Figure 65.

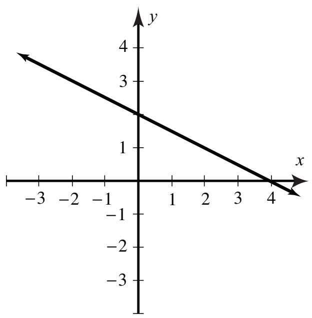



Figure 65

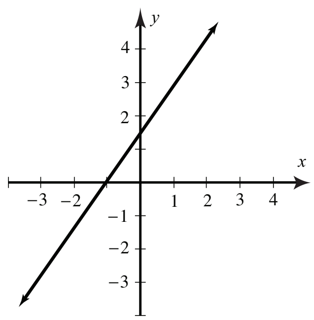



Figure 66

66. Let $\frac{2}{3}y - x = 1$.

$x$-intercept: Substitute $y = 0$ and solve for $x$. $\frac{2}{3}(0) - x = 1 \Rightarrow x = -1$; $x$-intercept: $-1$

$y$-intercept: Substitute $x = 0$ and solve for $y$. $\frac{2}{3}y - 0 = 1 \Rightarrow \frac{2}{3}y = 1 \Rightarrow y = \frac{3}{2}$; $y$-intercept: $\frac{3}{2}$

See Figure 66.

67. Let $y = 8x - 5$.

$x$-intercept: Substitute $y = 0$ and solve for $x$. $0 = 8x - 5 \Rightarrow 5 = 8x \Rightarrow x = \frac{5}{8}$; $x$-intercept: $\frac{5}{8}$

$y$-intercept: Substitute $x = 0$ and solve for $y$. $y = 8(0) - 5 \Rightarrow y = -5$; $y$-intercept: $-5$

See Figure 67.

68. Let $y = -1.5x + 15$.

$x$-intercept: Substitute $y = 0$ and solve for $x$. $0 = -1.5x + 15 \Rightarrow 1.5x = 15 \Rightarrow x = 10$; $y$-intercept: 10

$y$-intercept: Substitute $x = 0$ and solve for $y$. $y = -1.5(0) + 15 \Rightarrow y = 15$; $y$-intercept: 15

See Figure 68.

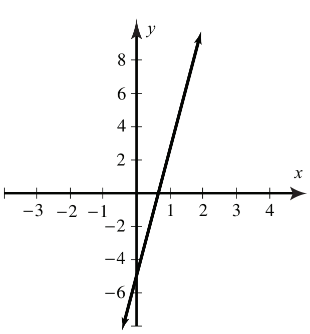



Figure 67

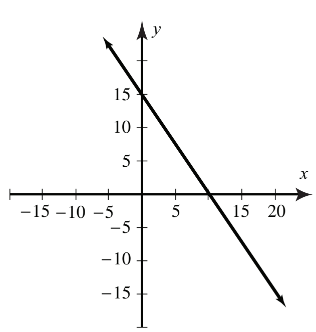



Figure 68

69. Let $\frac{x}{5} + \frac{y}{7} = 1$.

$x$-intercept: Substitute $y = 0$ and solve for $x$. $\frac{x}{5} + \frac{0}{7} = 1 \Rightarrow \frac{x}{5} = 1 \Rightarrow x = 5$; $x$-intercept: 5

$y$-intercept: Substitute $x = 0$ and solve for $y$. $\frac{0}{5} + \frac{y}{7} = 1 \Rightarrow \frac{y}{7} = 1 \Rightarrow y = 7$; $y$-intercept: 7

$a$ and $b$ represent the $x$- and $y$-intercepts, respectively.

70. Let $\frac{x}{2} + \frac{y}{3} = 1$.

$x$-intercept: Substitute $y = 0$ and solve for $x$. $\frac{x}{2} + \frac{0}{3} = 1 \Rightarrow \frac{x}{2} = 1 \Rightarrow x = 2$; $x$-intercept: 2

$y$-intercept: Substitute $x = 0$ and solve for $y$. $\frac{0}{2} + \frac{y}{3} = 1 \Rightarrow \frac{y}{3} = 1 \Rightarrow y = 3$; $y$-intercept: 3

$a$ and $b$ represent the $x$- and $y$-intercepts, respectively.

71. Let $\frac{2x}{3} + \frac{4y}{5} = 1$.

$x$-intercept: Substitute $y = 0$ and solve for $x$. $\frac{2x}{3} + \frac{4(0)}{5} = 1 \Rightarrow \frac{2x}{3} = 1 \Rightarrow x = \frac{3}{2}$; $x$-intercept: $\frac{3}{2}$

$y$-intercept: Substitute $x = 0$ and solve for $y$. $\frac{2(0)}{3} + \frac{4y}{5} = 1 \Rightarrow \frac{4y}{5} = 1 \Rightarrow y = \frac{5}{4}$; $y$-intercept: $\frac{5}{4}$

$a$ and $b$ represent the $x$- and $y$-intercepts, respectively.

72. Let $\frac{5x}{6} - \frac{y}{2} = 1$.

$x$-intercept: Substitute $y = 0$ and solve for $x$. $\frac{5x}{6} - \frac{0}{2} = 1 \Rightarrow \frac{5x}{6} = 1 \Rightarrow x = \frac{6}{5}$; $x$-intercept: $\frac{6}{5}$

$y$-intercept: Substitute $x = 0$ and solve for $y$. $\frac{5(0)}{6} - \frac{y}{2} = 1 \Rightarrow -\frac{y}{2} = 1 \Rightarrow y = -2$; $y$-intercept: $-2$

$a$ and $b$ represent the $x$- and $y$-intercepts, respectively.

73. $\frac{x}{a} + \frac{y}{b} = 1$; $x$-intercept: $5 \Rightarrow a = 5$, $y$-intercept: $9 \Rightarrow b = 9$; $\frac{x}{5} + \frac{y}{9} = 1$

74. $\frac{x}{a} + \frac{y}{b} = 1$; $x$-intercept: $\frac{2}{3} \Rightarrow a = \frac{2}{3}$, $y$-intercept: $-\frac{5}{4} \Rightarrow b = -\frac{5}{4}$; $\frac{x}{\frac{2}{3}} + \frac{y}{-\frac{5}{4}} = 1 \Rightarrow \frac{3x}{2} - \frac{4y}{5} = 1$

75. (a) Since the point (0, –3.2) is on the graph, the $y$-intercept is –3.2. The data is exactly linear, so one can use any two points to determine the slope. Using the points (0, –3.2) and (1, –1.7), $m = \frac{-1.7 - (-3.2)}{1 - 0} = 1.5$. The slope-intercept form of the line is $y = 1.5x - 3.2$.

(b) When $x = -2.7$, $y = 1.5(-2.7) - 3.2 = -7.25$. This calculation involves interpolation.

When $x = 6.3$, $y = 1.5(6.3) - 3.2 = 6.25$. This calculation involves extrapolation.

76. (a) Since the point (0, 6.8) is on the graph, the $y$-intercept is 6.8. The data is exactly linear, so one can use any two points to determine the slope. Using the points (0, 6.8) and (1, 5.1), $m = \frac{5.1 - 6.8}{1 - 0} = -1.7$. The slope-intercept form of the line is $y = -1.7x + 6.8$.

(b) When $x = -2.7$, $y = -1.7(-2.7) + 6.8 = 11.39$. This calculation involves extrapolation.

When $x = 6.3$, $y = -1.7(6.3) + 6.8 = -3.91$. This calculation involves extrapolation.

77. (a) Since the data is exactly linear, one can use any two points to determine the slope. Using the points (5, 94.7) and (23, 56.9), $m = \dfrac{56.9 - 94.7}{23 - 5} = -2.1$. The point-slope form of the line is $y = -2.1(x - 5) + 94.7$ and the slope-intercept form of the line is $y = -2.1x + 105.2$.

(b) When $x = -2.7$, $y = -2.1(-2.7) + 105.2 = 110.87$. This calculation involves extrapolation.

When $x = 6.3$, $y = -2.1(6.3) + 105.2 = 91.97$. This calculation involves interpolation.

78. (a) Since the data is exactly linear, one can use any two points to determine the slope. Using the points (–3, –0.9) and (2, 8.6), $m = \dfrac{8.6 - (-0.9)}{2 - (-3)} = 1.9$. The point-slope form of the line is $y = 1.9(x - 2) + 8.6$ and the slope-intercept form of the line is $y = 1.9x + 4.8$.

(b) When $x = -2.7$, $y = 1.9(-2.7) + 4.8 = -0.33$. This calculation involves interpolation.

When $x = 6.3$, $y = 1.9(6.3) + 4.8 = 16.77$. This calculation involves extrapolation.

79. (a) The slope between (1998, 3305) and (1999, 3185) is –120, and the slope between (1999, 3185) and (2000, 3089) is –96. Using the average of –120 and –96, we will let $m = -108$.

$f(x) = -108(x - 1998) + 3305$, or $f(x) = -108x + 219{,}089$ approximately models the data.

*Answers may vary.*

(b) $f(2005) = -108(2005) + 219{,}089 = 2549$; this estimated value is too low (compared to the actual value of 3450); this estimate involved extrapolation.

(c) Numbers were decreasing but increased after 911.

80. (a) The slope between (1998, 43) and (1999, 26) is –17, and the slope between (1999, 26) and (2000, 9) is –17; letting $m = -17$, $f(x) = -17(x - 1998) + 43$, or $f(x) = -17x + 34{,}009$ exactly models the data.

(b) $f(2003) = -17(2003) + 34{,}009 = -42$; this estimated value is not possible. Extrapolation.

(c) *Answers may vary.*

81. (a) Find the slope: $m = \dfrac{37{,}000 - 25{,}000}{2010 - 2003} = \dfrac{12{,}000}{7}$. Using the first point $(2003, 25000)$ for $(x_1, y_1)$ and $m = \dfrac{12{,}000}{7}$, we get $y = \dfrac{12{,}000}{7}(x - 2003) + 25{,}000$. The cost of attending a private college or university is increasing by $\dfrac{12{,}000}{7} \approx \$1714$ per year on average.

(b) $y = \dfrac{12{,}000}{7}(2007 - 2003) + 25{,}000 \Rightarrow y = \dfrac{12{,}000}{7}(4) + 25{,}000 \Rightarrow y \approx 6857 + 25{,}000 \Rightarrow$

$y \approx \$31{,}857$; interpolation

(c) $y = \dfrac{12{,}000}{7}(x - 2003) + 25{,}000 \Rightarrow y \approx \dfrac{12{,}000}{7}x - 3{,}433{,}714 + 25{,}000 \Rightarrow$

$y \approx 1714x - 3{,}408{,}714$ (approximate)

82. (a) The average rate of change $= \dfrac{161 - 128}{4 - 1} = \dfrac{33}{3} = 11 \Rightarrow$ the biker is traveling 11 mile per hour.

(b) Using $m = 11$ and the point $(1, 128)$, we get $y = 11(x - 1) + 128 = 11x - 11 + 128 \Rightarrow$

$y = 11x + 117$.

(c) Find the $y$-intercept in $y = 11x + 117 \Rightarrow b = 117$; the biker is initially 117 miles from the interstate highway.

(d) 1 hour and 15 minutes = 1.25 hours; $y = 11(1.25) + 117 = 13.75 + 117 = 130.75$; the biker is 130.75 miles from the interstate highway after 1 hour and 15 minutes.

83. (a) Find the slope: $m = \dfrac{3.6 - 1.6}{2005 - 2002} = \dfrac{2}{3}$. Using the first point $(2002, 1.6)$ for $(x_1, y_1)$ and $m = \dfrac{2}{3}$, we get $y = \dfrac{2}{3}(x - 2002) + 1.6$; online music sales increased by $\dfrac{2}{3}$ billion dollars $\approx$ \$0.67 billion per year on average.

(b) $y = \dfrac{2}{3}(2008 - 2002) + 1.6 \Rightarrow y = \dfrac{2}{3}(6) + 1.6 \Rightarrow y = 4 + 1.6 \Rightarrow y = 5.6$ or \$5.6 billion; extrapolation

(c) $y = \dfrac{2}{3}(x - 2002) + 1.6 \Rightarrow y = \dfrac{2}{3}x - \dfrac{4004}{3} + \dfrac{8}{5} \Rightarrow y = \dfrac{2}{3}x - \dfrac{19{,}996}{15}$

84. (a) Water is leaving the tank because the amount of water in the tank is decreasing. After 3 minutes there are approximately 70 gallons of water in the tank.

(b) The $x$-intercept is 10. This means that after 10 minutes the tank is empty. The $y$-intercept is 100. This means that initially there are 100 gallons of water in the tank.

(c) To determine the equation of the line, we can use 2 points. The points (0, 100) and (10, 0) lie on the line. The slope of this line is $m = \dfrac{0 - 100}{10 - 0} = -10$. This slope means the water is being drained at a rate of 10 gallons per minute. Since the $y$-intercept is 100, the slope-intercept form of this line is given by $y = -10x + 100$.

(d) From the graph, when $y = 50$ the $x$-value appears to be 5. Symbolically, when $y = 50$ then $-10x + 100 = 50 \Rightarrow -10x = -50 \Rightarrow x = 5$. The $x$-coordinate is 5.

85. (a) See Figure 85.

(b) Use the first and last points to find slope $m = \dfrac{8.8 - 1.0}{2004 - 1999} = \dfrac{7.8}{5} = 1.56$. Now using the first point $(1999, 1.0)$ for $(x_1, y_1)$ and $m = 1.56$, we get $y = 1.56(x - 1999) + 1.0$. The daily worldwide spam message numbers increased 1.56 billion per year on average. *Answers may vary.*

(c) $y = 1.56(2007 - 1999) + 1.0 \Rightarrow y = 1.56(8) + 1.0 \Rightarrow y = 12.48 + 1 \Rightarrow y \approx 13.5$ billion. *Answers may vary.*

86. (a) See Figure 86.

(b) Using the second and fourth points, $f(x) = 149.3(x - 1985) + 1318$; The average cost of tuition and fees at public four-year colleges has increased by about \$149 per year.

(c) In 1992, the average cost of tuition and fees was $f(1992) = 149(1992 - 1985) + 1318 \Rightarrow f(1992) = 149.3(7) + 1318 \Rightarrow f(1992) \approx \$2361$. This is fairly close to the actual of \$2334.

(d) The 2005 value; it is too large.

[1998, 2005, 1] by [0, 10, 1]

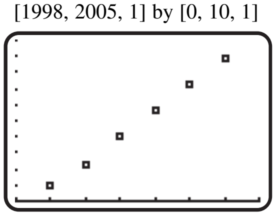


Figure 85

[1978, 2006, 2] by [0, 6000, 500]

Figure 86

87. (a) See Figure 87.

(b) Use the first and last points to find slope $m = \dfrac{2 - 1.4}{2004 - 1998} = \dfrac{0.6}{6} = 0.1$. Now using the first point and slope $m = 0.1$, we get $y = 0.1(x - 1998) + 1.4$. U.S. sales of Toyota vehicles has increased by 0.1 million per year.

(c) $f(x)$ is an exact model for the listed data.

[1997, 2005, 1] by [0, 2.2, 0.2]

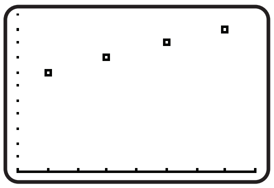


Figure 87

[1995, 2006, 1] by [9, 14, 1]

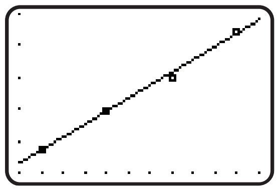


Figure 91

[1940, 2000, 10] by [10, 60, 10]

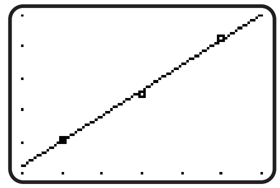


Figure 92

88. (a) $m = 280$ and $(1988, 4000)$ is a data point; $y = 280(x - 1988) + 4000$.

(b) Let $x = 1975 \Rightarrow y = 280(1975 - 1988) + 4000 = 360$; the number of incidents in 1975 was 360.

89. (a) The annual fixed cost would be $350 \times 12 = \$4200$. The variable cost of driving $x$ miles is $0.29x$. Thus, $f(x) = 0.29x + 4200$.

(b) The $y$-intercept is 4200, which represents the annual fixed costs. This means that even if the car is not driven, it will still cost \$4200 each year to own it.

90. (a) The line passes through the points (1970, 8.46) and (2005, 8.18). The slope of this line is $m = \dfrac{8.18 - 8.46}{2005 - 1970} = \dfrac{0.28}{-35} = -0.008$. A point-slope form for the equation of the line is $y = -0.008(x - 1970) + 8.46$.

(b) Wages have decreased by about \$0.008 per year.

(c) When $x = 2000$, $y = -0.008(2000 - 1970) + 8.46 = \$8.22$. This is more than the actual value.

91. (a) Scatterplot the data in the table.

(b) Start by picking a data point for the line to pass through. If we choose (1996, 9.7), $f$ is represented by $f(x) = m(x - 1996) + 9.7$. Using trial and error, the slope m is between 0 and 1. Let $m = 0.42$. The graph of $f$ together with the scatterplot is shown in Figure 91. *Answers may vary.*

(c) A slope of $m \approx 0.42$ means that Asian-American population is predicted to increase by approximately 0.42 million (420,000) people each year.

(d) To predict the population in the year 2008, evaluate $f(2008) = 0.4167(2008 - 1996) + 9.7 \approx 14.7$ million people.

92. (a) Scatterplot the data in the table.

(b) Start by picking a data point for the line to pass through. If we choose (1950, 20.2), $f$ is represented by $f(x) = m(x - 1950) + 20.2$. Using trial and error, the slope $m$ is between 0.5 and 1.5. Let $m = 0.815$. The graph of $f$ together with the scatterplot is shown in Figure 92. *Answers may vary.*

(c) A slope of $m \approx 0.815$ means that population in the western states of the United States has increased by approximately 0.82 million people each year.

(d) To predict the population in the year 2010, evaluate $f(2010) = 0.815(2010 - 1950) + 20.2 = 69.1$ million people.

93. (a) Graph $Y_1 = X/1024 + 1$ in $[0, 3, 1]$ by $[-2, 2, 1]$ as in Figure 93. The line appears to be horizontal in this viewing rectangle, however, we know that the graph of the line is not horizontal because its slope is $\frac{1}{1024} \neq 0$.

(b) The resolution of most graphing calculator screens is not good enough to show the slight increase in the $y$-values. Since the $x$-axis is 3 units long, this increase in $y$-values amounts to only $\frac{1}{1024} \times 3 \approx 0.003$ units, which does not show up on the screen.

[0, 3, 1] by [–2, 2, 1]

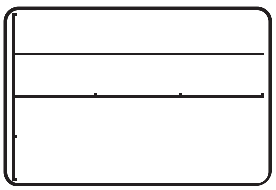


Figure 93

[–10, 10, 1] by [–10, 10, 1]

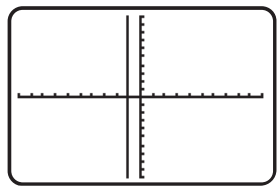


Figure 94

94. (a) The graph appears to be the vertical line $x = -1$. However, the line actually is not vertical, since it has slope of 1000, which is defined. See Figure 94.

(b) The resolution of most graphing calculator screens is not good enough to show that the line is slightly non-vertical on the interval [–10, 10].

95. (a) From Figure 95a, one can see that the lines do not appear to be perpendicular.

(b) The lines are graphed in the specified viewing rectangles and shown in Figures 95b-d, respectively. In the windows [–15, 15, 1] by [–10, 10, 1] and [–3, 3, 1] by [–2, 2, 1] the lines appear to be perpendicular.

(c) The lines appear perpendicular when the distance shown along the $x$-axis is approximately 1.5 times the distance along the $y$-axis. For example, in window [–12, 12,1] by [–8, 8, 1], the lines will appear perpendicular. The distance along the $x$-axis is 24 while the distance along the y-axis is 16. Notice that $1.5 \times 16 = 24$. This is called a “square window” and can be set automatically on some graphing calculators.

[–10, 10, 1] by [–10, 10, 1]

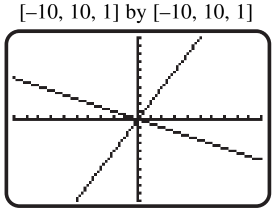


Figure 95a

[–15, 15, 1] by [–10, 10, 1]

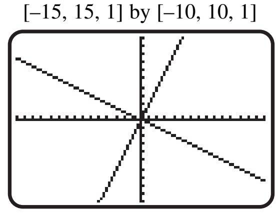


Figure 95b

[–10, 10, 1] by [–3, 3, 1]

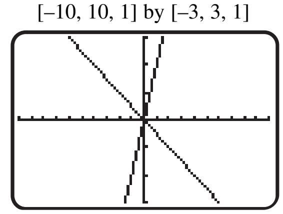


Figure 95c

[–3, 3, 1] by [–2, 2, 1]

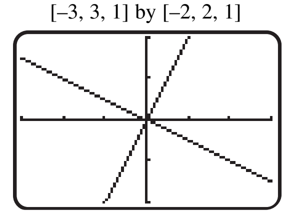


Figure 95d

96. The circle will appear to be a circle rather than an ellipse for the window [–9, 9, 1] by [–6, 6, 1], since the distance along the $x$-axis is 18, which is 1.5 times the distance along the $y$-axis, 12. Similarly, a circle will result in the viewing window [–18, 18, 1] by [–12, 12, 1]. The results are shown in Figures 96a-d.

[–9, 9, 1] by [–6, 6, 1]

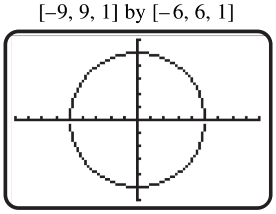


Figure 96a

[–5, 5, 1] by [–10, 10, 1]

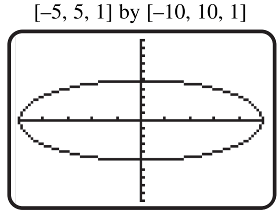


Figure 96b

[–5, 5, 1] by [–5, 5, 1]

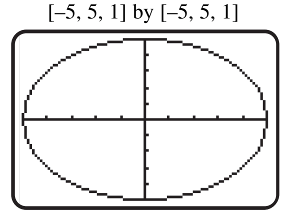


Figure 96c

[–18, 18, 1] by [–12, 12, 1]

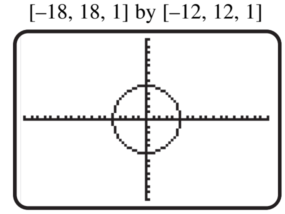


Figure 96d

97. (i) The slope of the line connecting (0, 0) and (2, 2) is 1. Let $y_1 = x$.

(ii) A second line passing through (0, 0) has a slope of $-1$. Let $y_2 = -x$.

(iii) A third line passing through (1, 3) has a slope of 1. Let $y_3 = (x - 1) + 3 = x + 2$.

(iv) A fourth line passing through (2, 2) has a slope of –1. Let $y_4 = -(x - 2) + 2 = -x + 4$.

98. (i) The slope of the line connecting (1, 1) and (5, 1) is 0. Let $y_1 = 1$.

(ii) A second line passing through (1, 1) is vertical. Its equation is $x = 1$.

(iii) A third line passing through (5, 1) is vertical. Its equation is $x = 5$.

(iv) A fourth line passing through (5, 5) is horizontal. Let $y_4 = 5$.

99. (i) The slope of the line connecting (–4, 0) and (0, 4) is 1. Let $y_1 = x + 4$.

(ii) A second line passing through (4, 0) and (0, –4) has a slope of 1. Let $y_2 = x - 4$.

(iii) A third line passing through (0, –4) and (–4, 0) has a slope of –1. Let $y_3 = -x - 4$.

(iv) A fourth line passing through (0, 4) and (4, 0) is –1. Let $y_4 = -x + 4$.

100. (i) The slope of the line connecting (1, 1) and (2, 3) is 2. Let $y_1 = 2(x - 1) + 1$.

(ii) The second line is perpendicular to $y_1$ and passes through (1, 1). Let $y_2 = -\frac{1}{2}(x - 1) + 1$.

(iii) The third line is perpendicular to $y_1$ and passes through (2, 3). Let $y_3 = -\frac{1}{2}(x - 2) + 3$.

(iv) The fourth line is parallel to $y_1$ and passes through (3.5, 1). Let $y_4 = 2(x - 3.5) + 1$.

101. Since $y$ is directly proportional to $x$, the variation equation $y = kx$ must hold. To find the value of $k$, use the value $y = 7$ when $x = 14$. Solve the equation $7 = k(14) \Rightarrow k = \frac{1}{2}$. Then $y = \frac{1}{2}(5) = \frac{5}{2} = 2.5$.

102. Since $y$ is directly proportional to $x$, the variation equation $y = kx$ must hold. To find the value of $k$, use the value $y = 13$ when $x = 10$. Solve the equation $13 = k(10) \Rightarrow k = \frac{13}{10}$. Then $y = \frac{13}{10}(2.5) = 3.25$.

103. Since $y$ is directly proportional to $x$, the variation equation $y = kx$ must hold. To find the value of $k$, use the value $y = \frac{3}{2}$ when $x = \frac{2}{3}$. Solve the equation $\frac{3}{2} = k\left(\frac{2}{3}\right) \Rightarrow k = \frac{9}{4}$. Then $y = \frac{9}{4}\left(\frac{1}{2}\right) = \frac{9}{8}$.

104. Since $y$ is directly proportional to $x$, the variation equation $y = kx$ must hold. To find the value of $k$, use the value $y = 7.2$ when $x = 5.2$. Solve the equation $7.2 = k(5.2) \Rightarrow k = \frac{7.2}{5.2}$. Then $y = \frac{7.2}{5.2}(1.3) = 1.8$.

105. Since $y$ is directly proportional to $x$, the variation equation $y = kx$ must hold. To find the value of $k$ use the value $y = 7.5$ when $x = 3$ from the table. Solve the equation $7.5 = k(3) \Rightarrow k = 2.5$. The variation equation is $y = 2.5x$ and hence $y = 2.5(8) = 20$ when $x = 8$. A graph of $Y_1 = 2.5X$ together with the data points is shown in Figure 105.

106. Since $y$ is directly proportional to $x$, the variation equation $y = kx$ must hold. To find the value of $k$ use the value $y = 3.96$ when $x = 1.2$ from the table. Solve the equation $3.96 = k(1.2) \Rightarrow k = 3.3$. The variation equation is $y = 3.3x$ and hence when $y = 23.43$, $x = \frac{23.43}{3.3} = 7.1$. A graph of $Y_1 = 3.3X$ together with the data points is shown in Figure 106.

[0, 10, 1] by [0, 24, 2]

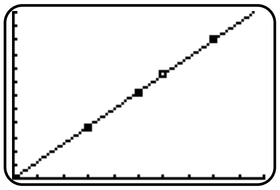


Figure 105

[0, 10, 1] by [0, 30, 2]

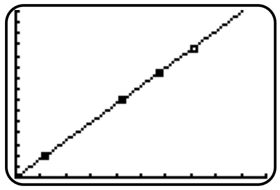


Figure 106

[0, 100, 10] by [0, 6, 1]

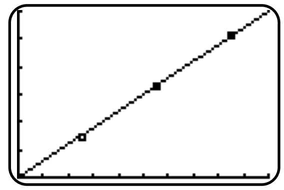


Figure 107

[0, 6, 1] by [0, 80, 10]

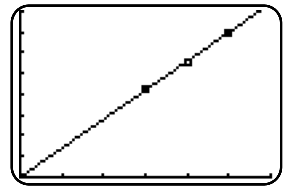


Figure 108

107. Since $y$ is directly proportional to $x$, the variation equation $y = kx$ must hold. To find the value of $k$ use the value $y = 1.50$ when $x = 25$ from the table. Solve the equation $1.50 = k(25) \Rightarrow k = 0.06$. The variation equation is $y = 0.06x$ and hence when $y = 5.10$, $x = \frac{5.1}{0.06} = 85$. A graph of $Y_1 = 0.06X$ together with the data points is shown in Figure 107.

108. Since $y$ is directly proportional to $x$, the variation equation $y = kx$ must hold. To find the value of $k$ use the value $y = 41.97$ when $x = 3$ from the table. Solve the equation $41.97 = k(3) \Rightarrow k = 13.99$. The variation equation is $y = 13.99x$ and hence $y = 13.99(5) = 69.95$ when $x = 5$. A graph of $Y_1 = 13.99X$ together with the data points is shown in Figure 108.

109. Let $y$ represent the cost of tuition and $x$ represent the number of credits taken. Since the cost of tuition is directly proportional to the number of credits taken, the variation equation $y = kx$ must hold. If cost $y = \$720.50$ when the number of credits $x = 11$, we find the constant of proportionality $k$ by solving $720.50 = k(11) \Rightarrow k = 65.50$. The variation equation is $y = 65.50x$. Therefore, the cost of taking 16 credits is $y = 65.50(16) = \$1048$.

110. Let $y$ represent the maximum load and $x$ represent the beam width. Since the maximum load is directly proportional to the beam width, the variation equation $y = kx$ must hold. If the maximum load is $y = 250$ pounds when the beam width $x = 1.5$ inches, we find the constant of proportionality $k$ by solving $250 = k(1.5) \Rightarrow k = 166\frac{2}{3}$. The variation equation is $y = 166\frac{2}{3}x$. Therefore, a 3.5 inch beam can support a maximum load of $y = 166\frac{2}{3}(3.5) = 583\frac{1}{3}$ pounds.

111. (a) Since the points (0, 0) and (300, 3) lie on the graph of $y = kx$, the slope of the graph is $\frac{3 - 0}{300 - 0} = 0.01$ and $y = 0.01x$, so $k = 0.01$.

(b) $y = 0.01(110) = 1.1$ millimeters.

112. $25 = 10k \Rightarrow k = 2.5$; then $195 = 2.5x \Rightarrow 78$.

113. (a) Using $F = kx \Rightarrow 15 = k(8) \Rightarrow k = \frac{15}{8}$

(b) The variation equation is $y = \frac{15}{8}x$; $25 = \frac{15}{8}(x) \Rightarrow x = 13\frac{1}{3}$ inches.

114. Using $F = kx \Rightarrow 80 = k(3) \Rightarrow k = \frac{80}{3}$; then $x = 7 \Rightarrow F = \frac{80}{3}(7) = 186.\overline{6}$.

115. (a) For $(150, 26)$, $\frac{F}{x} = \frac{26}{150} \approx 0.173$; for $(180, 31)$, $\frac{F}{x} = \frac{31}{180} \approx 0.172$; for $(210, 36)$, $\frac{F}{x} = \frac{36}{210} \approx 0.171$; for $(320, 54)$, $\frac{F}{x} = \frac{54}{320} \approx 0.169$; the ratios give the force needed to push a 1 lb box.

(b) From the table it appears that approximately 0.17 lb of force is needed to push a 1 lb cargo box $\Rightarrow$ $k = 0.17$.

(c) See Figure 115.

(d) $F \approx 0.17(275) \Rightarrow F = 46.75$ lbs of force.

[125, 350, 25] by [0, 75, 5]

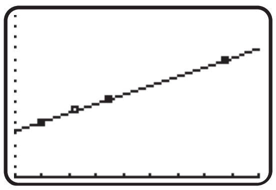


Figure 115

116. Let $y$ represent the resistance and $x$ represent the wire length. Since the resistance is directly proportional to the length, the variation equation $y = kx$ must hold. If the resistance $y = 1.2$ ohms when the length $x = 255$ feet, we find the constant of proportionality $k$ by solving $1.2 = k(255) \Rightarrow k \approx 0.0047059$. The variation equation is $y \approx 0.0047059x$. A 135-foot wire will have a resistance of $y \approx 0.0047059(135) \approx 0.6353$ ohm. The constant of proportionality represents the resistance of the wire in ohms per foot.

## Extended and Discovery Exercises for Section 2.2

1. Let $x =$ number of fish in the sample and $y =$ number of tagged fish. Then $y = kx$, where $k$ represents the proportion of fish tagged. From the data point (94, 13), get $13 = k(94) \Rightarrow k \approx 0.138298$. Letting the sample represent the entire number of fish, we get $y = 0.138298x \Rightarrow 85 = 0.138298x \Rightarrow x \approx 615$.

2. Let $x =$ number of black birds in the sample and $y =$ number of tagged blackbirds. Then $y = kx$, where $k$ represents the proportion of blackbirds tagged. From the data point (32, 8), we get $8 = k(32) \Rightarrow k = 0.25$. Letting the sample represent the entire blackbird population, we get $y = 0.25x \Rightarrow 63 = 0.25x \Rightarrow x = 252$. There are about 252 blackbirds in the area.

## Checking Basic Concepts for Sections 2.1 and 2.2

1. $f(x) = 4 - 2x$. See Figure 1. Slope: –2; $y$-intercept: 4; $x$-intercept: 2

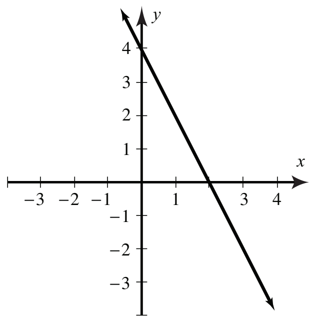



Figure 1

2. (a) The rate of change is 2.7 per 100,000 people, or 27 per 1,000,000 $\Rightarrow m = 27$; $f(x) = 27x$, where $x$ is in millions.

   (b) $f(39) = 27(39) = 1053$; the number of people 15 to 24 years old who die from heart disease is 1053.

3. Since the car is initially 50 miles south of home and driving south at 60 mph, the $y$-intercept is 50 and $m = 60$; $f(t) = 60t + 50$, where $t$ is in hours.

4. The slope of the line passing through (–3, 4) and (5, –2) is $m = \frac{-2 - 4}{5 - (-3)} = -\frac{3}{4}$. Using the point-slope form of a line results in $y = -\frac{3}{4}(x + 3) + 4$ or $y = -\frac{3}{4}x + \frac{7}{4}$. The line $y = -\frac{3}{4}x$ is parallel to $y = -\frac{3}{4}x + \frac{7}{4}$ and $y = \frac{4}{3}x$ is perpendicular. *Answers may vary.*

5. $y = 7$ is the equation of the horizontal line passing through (–4, 7) and $x = -4$ is the vertical line passing through this point.

6. Since the line passes through $(-1, 2)$ and $(1, -1)$, the slope is $m = \frac{2 - (-1)}{-1 - 1} = -\frac{3}{2}$. The $y$-intercept is $\frac{1}{2} \Rightarrow y = -\frac{3}{2}x + \frac{1}{2}$.

7. Let $-3x + 2y = -18$.
   $x$-intercept: Substitute $y = 0$ and solve for $x$. $-3x + 2(0) = -18 \Rightarrow -3x = -18 \Rightarrow x = 6$; $x$-intercept: 6
   $y$-intercept: Substitute $x = 0$ and solve for $y$. $-3(0) + 2y = -18 \Rightarrow 2y = -18 \Rightarrow y = -9$; $x$-intercept: $-9$

## 2.3: Linear Equations

1. $ax + b = 0 \Rightarrow ax = -b \Rightarrow x = \frac{-b}{a}$. This shows that the equation $ax + b = 0$ has only one solution.
2. Since the graph of $y = ax + b$ is a linear equation, the graph will intersect the $x$-axis at one point.
3. $4 - (5 - 4x) = 4 - 5 + 4x = -1 + 4x = 4x - 1$
4. $15x = 5 \Rightarrow \frac{1}{15}(15x) = \frac{1}{15}(5) \Rightarrow x = \frac{1}{3}$. This shows the multiplication property of equality.

5. The zero of f and the $x$-intercept of the graph of $f$ are equal. The zero of $f$ and the $x$-intercept of the graph of $f$ are both found by finding the value of $x$ when $y = 0$.
6. A contradiction has no solutions. For example, the equation $x + 2 = x$ has no solutions and is a contradiction. In an identity, every value of the variable is a solution. For example, the equation $x + x = 2x$ is an identity because every value for $x$ makes the equation true.
7. $3x - 1.5 = 7 \Rightarrow 3x - 1.5 - 7 = 0 \Rightarrow 3x - 8.5 = 0$; the equation is linear.
8. $100 - 23x = 20x \Rightarrow 100 - 23x - 20x = 0 \Rightarrow -43x + 100 = 0$; the equation is linear.
9. $2\sqrt{x} + 2 = 1$; since the equation cannot be written in the form $ax + b = 0$, it is nonlinear.
10. $4x^3 - 7 = 0$; since the equation cannot be written in the form $ax + b = 0$, it is nonlinear.
11. $7x - 5 = 3(x - 8) \Rightarrow 7x - 5 = 3x - 24 \Rightarrow 4x + 19 = 0$; the equation is linear.
12. $2(x - 3) = 4 - 5x \Rightarrow 2x - 6 = 4 - 5x \Rightarrow 7x - 10 = 0$; it is linear.
13. $2x - 8 = 0 \Rightarrow 2x = 8 \Rightarrow x = 4$ Check: $2(4) - 8 = 0 \Rightarrow 8 - 8 = 0 \Rightarrow 0 = 0$
14. $4x - 8 = 0 \Rightarrow 4x = 8 \Rightarrow x = 2$ Check: $4(2) - 8 = 0 \Rightarrow 8 - 8 = 0 \Rightarrow 0 = 0$
15. $-5x + 3 = 23 \Rightarrow -5x = 20 \Rightarrow x = -4$ Check: $-5(-4) + 3 = 23 \Rightarrow 20 + 3 = 23 \Rightarrow 23 = 23$
16. $-9x - 3 = 24 \Rightarrow -9x = 27 \Rightarrow x = -3$ Check: $-9(-3) - 3 = 24 \Rightarrow 27 - 3 = 24 \Rightarrow 24 = 24$
17. $4(z - 8) = z \Rightarrow 4z - 32 = z \Rightarrow 3z = 32 \Rightarrow z = \frac{32}{3}$ Check: $4\left(\frac{32}{3} - 8\right) = \frac{32}{3} \Rightarrow 4\left(\frac{8}{3}\right) = \frac{32}{3} \Rightarrow$
$\frac{32}{32} = \frac{32}{32}$
18. $-3(2z - 1) = 2z \Rightarrow -6z + 3 = 2z \Rightarrow -8z = -3 \Rightarrow z = \frac{3}{8}$ Check: $-3\left(2\left(\frac{3}{8}\right) - 1\right) = 2\left(\frac{3}{8}\right) \Rightarrow$
$-3\left(-\frac{1}{4}\right) = \frac{3}{4} \Rightarrow \frac{3}{4} = \frac{3}{4}$
19. $-5(3 - 4t) = 65 \Rightarrow -15 + 20t = 65 \Rightarrow 20t = 80 \Rightarrow t = 4$ Check: $-5[3 - 4(4)] = 65 \Rightarrow$
$-5(3 - 16) = 65 \Rightarrow -5(-13) = 65 \Rightarrow 65 = 65$
20. $6(5 - 3t) = 66 \Rightarrow 30 - 18t = 66 \Rightarrow -18t = 36 \Rightarrow t = -2$ Check: $6[5 - 3(-2)] = 66 \Rightarrow$
$6(11) = 66 \Rightarrow 66 = 66$
21. $k + 8 = 5k - 4 \Rightarrow -4k = -12 \Rightarrow k = 3$ Check: $3 + 8 = 5(3) - 4 \Rightarrow 11 = 15 - 4 \Rightarrow 11 = 11$
22. $2k - 3 = k + 3 \Rightarrow k = 6$ Check: $2(6) - 3 = 6 + 3 \Rightarrow 12 - 3 = 9 \Rightarrow 9 = 9$
23. $2(1 - 3x) + 1 = 3x \Rightarrow 2 - 6x + 1 = 3x \Rightarrow -6x + 3 = 3x \Rightarrow -9x = -3 \Rightarrow x = \frac{1}{3}$
Check: $2\left[1 - 3\left(\frac{1}{3}\right)\right] + 1 = 3\left(\frac{1}{3}\right) \Rightarrow 2(1 - 1) + 1 = 1 \Rightarrow 0 + 1 = 1 \Rightarrow 1 = 1$
24. $5(x - 2) = -2(1 - x) \Rightarrow 5x - 10 = -2 + 2x \Rightarrow 3x = 8 \Rightarrow x = \frac{8}{3}$
Check: $5\left(\frac{8}{3} - 2\right) = -2\left(1 - \frac{8}{3}\right) \Rightarrow 5\left(\frac{2}{3}\right) = -2\left(-\frac{5}{3}\right) \Rightarrow \frac{10}{3} = \frac{10}{3}$

25. $-5(3-2x)-(1-x)=4(x-3) \Rightarrow -15+10x-1+x=4x-12 \Rightarrow 11x-16=4x-12 \Rightarrow$
$7x=4 \Rightarrow x=\frac{4}{7}$ Check: $-5\left[3-2\left(\frac{4}{7}\right)\right]-\left(1-\frac{4}{7}\right)=4\left(\frac{4}{7}-3\right) \Rightarrow$
$-5\left(\frac{13}{7}\right)-\frac{3}{7}=4\left(-\frac{17}{7}\right) \Rightarrow -\frac{65}{7}-\frac{3}{7}=-\frac{68}{7} \Rightarrow -\frac{68}{7}=-\frac{68}{7}$

26. $-3(5-x)-(x-2)=7x-2 \Rightarrow -15+3x-x+2=7x-2 \Rightarrow 2x-13=7x-2 \Rightarrow$
$-5x=11 \Rightarrow x=-\frac{11}{5}$ Check: $-3\left[5-\left(-\frac{11}{5}\right)\right]-\left(-\frac{11}{5}-2\right)=7\left(-\frac{11}{5}\right)-2 \Rightarrow$
$-3\left(\frac{36}{5}\right)-\left(-\frac{21}{5}\right)=-\frac{77}{5}-2 \Rightarrow -\frac{108}{5}+\frac{21}{5}=-\frac{87}{5} \Rightarrow -\frac{87}{5}=-\frac{87}{5}$

27. $-4(5x-1)=8-(x+2) \Rightarrow -20x+4=8-x-2 \Rightarrow -20x+4=6-x \Rightarrow -19x=2 \Rightarrow$
$x=-\frac{2}{19}$ Check: $-4\left[5\left(-\frac{2}{19}\right)-1\right]=8-\left(-\frac{2}{19}+2\right) \Rightarrow -4\left(-\frac{10}{19}-1\right)=8+\frac{2}{19}-2 \Rightarrow$
$\frac{40}{19}+4=6+\frac{2}{19} \Rightarrow \frac{116}{19}=\frac{116}{19}$

28. $6(3-2x)=1-(2x-1) \Rightarrow 18-12x=1-2x+1 \Rightarrow 18-12x=2-2x \Rightarrow 16=10x \Rightarrow$
$x=\frac{16}{10}=\frac{8}{5}$ Check: $6\left[3-2\left(\frac{8}{5}\right)\right]=1-\left[2\left(\frac{8}{5}\right)-1\right] \Rightarrow 6\left(3-\frac{16}{5}\right)=1-\left(\frac{16}{5}-1\right) \Rightarrow$
$6\left(-\frac{1}{5}\right)=1-\left(\frac{11}{5}\right) \Rightarrow -\frac{6}{5}=-\frac{6}{5}$

29. $\frac{2}{7}n+\frac{1}{5}=\frac{4}{7} \Rightarrow \frac{2}{7}n=\frac{13}{35} \Rightarrow n=\frac{13}{10}$ Check: $\frac{2}{7}\left(\frac{13}{10}\right)+\frac{1}{5}=\frac{4}{7} \Rightarrow \frac{26}{70}+\frac{1}{5}=\frac{4}{7} \Rightarrow \frac{40}{70}=\frac{4}{7} \Rightarrow$
$\frac{4}{7}=\frac{4}{7}$

30. $\frac{6}{11}-\frac{2}{33}n=\frac{5}{11}n \Rightarrow -\frac{17}{33}n=-\frac{6}{11} \Rightarrow n=\frac{18}{17}$ Check: $\frac{6}{11}-\frac{2}{33}\left(\frac{18}{17}\right)=\frac{5}{11}\left(\frac{18}{17}\right) \Rightarrow$
$\frac{6}{11}-\frac{36}{561}=\frac{90}{187} \Rightarrow \frac{270}{561}=\frac{90}{187} \Rightarrow \frac{90}{187}=\frac{90}{187}$

31. $\frac{1}{2}(d-3)-\frac{2}{3}(2d-5)=\frac{5}{12} \Rightarrow \frac{1}{2}d-\frac{3}{2}-\frac{4}{3}d+\frac{10}{3}=\frac{5}{12} \Rightarrow -\frac{5}{6}d+\frac{11}{6}=\frac{5}{12} \Rightarrow$
$-\frac{5}{6}d=-\frac{17}{12} \Rightarrow d=\frac{17}{10}$
Check: $\frac{1}{2}\left(\frac{17}{10}-3\right)-\frac{2}{3}\left[2\left(\frac{17}{10}\right)-5\right]=\frac{5}{12} \Rightarrow \frac{1}{2}\left(-\frac{13}{10}\right)-\frac{2}{3}\left(\frac{34}{10}-5\right)=\frac{5}{12} \Rightarrow$
$\frac{1}{2}\left(-\frac{13}{10}\right)-\frac{2}{3}\left(-\frac{16}{10}\right)=\frac{5}{12} \Rightarrow -\frac{13}{20}+\frac{32}{30}=\frac{5}{12} \Rightarrow \frac{25}{60}=\frac{5}{12} \Rightarrow \frac{5}{12}=\frac{5}{12}$

32. $\frac{7}{3}(2d-1)-\frac{2}{5}(4-3d)=\frac{1}{5}d \Rightarrow \frac{14}{3}d-\frac{7}{3}-\frac{8}{5}+\frac{6}{5}d=\frac{1}{5}d \Rightarrow \frac{88}{15}d-\frac{59}{15}=\frac{1}{5}d \Rightarrow \frac{85}{15}d=\frac{59}{15} \Rightarrow$
$d=\frac{59}{85}$ Check: $\frac{7}{3}\left[2\left(\frac{59}{85}\right)-1\right]-\frac{2}{5}\left[4-3\left(\frac{59}{85}\right)\right]=\frac{1}{5}\left(\frac{59}{85}\right) \Rightarrow$
$\frac{7}{3}\left(\frac{118}{85}-1\right)-\frac{2}{5}\left(4-\frac{177}{85}\right)=\frac{59}{425} \Rightarrow \frac{7}{3}\left(\frac{33}{85}\right)-\frac{2}{5}\left(\frac{163}{85}\right)=\frac{59}{425} \Rightarrow \frac{59}{425}=\frac{59}{125}$

33. $\frac{x-5}{3}+\frac{3-2x}{2}=\frac{5}{4} \Rightarrow 12\left(\frac{x-5}{3}+\frac{3-2x}{2}\right)=12\left(\frac{5}{4}\right) \Rightarrow 4x-20+18-12x=15 \Rightarrow$
$-8x-2=15 \Rightarrow -8x=17 \Rightarrow x=-\frac{17}{8}$ Check: $\frac{-\frac{17}{8}-5}{3}+\frac{3-2(-\frac{17}{8})}{2}=\frac{5}{4} \Rightarrow$
$\frac{-\frac{57}{8}}{3}+\frac{3+\frac{34}{8}}{2}=\frac{5}{4} \Rightarrow -\frac{19}{8}+\frac{\frac{58}{8}}{2}=\frac{5}{4} \Rightarrow -\frac{19}{8}+\frac{29}{8}=\frac{5}{4} \Rightarrow \frac{10}{8}=\frac{5}{4} \Rightarrow \frac{5}{4}=\frac{5}{4}$

34. $\frac{3x-1}{5}-2=\frac{2-x}{3} \Rightarrow 15\left(\frac{3x-1}{5}-2\right)=15\left(\frac{2-x}{3}\right) \Rightarrow 9x-3-30=10-5x \Rightarrow 14x=43 \Rightarrow$
$x=\frac{43}{14}$ Check: $\frac{3(\frac{43}{14})-1}{5}-2=\frac{2-\frac{43}{14}}{3} \Rightarrow \frac{\frac{129}{14}-1}{5}-2=\frac{2-\frac{43}{14}}{3} \Rightarrow \frac{\frac{115}{14}}{5}-2=\frac{-\frac{15}{14}}{3} \Rightarrow$
$\frac{23}{14}-\frac{28}{14}=\frac{-5}{14} \Rightarrow \frac{-5}{14}=\frac{-5}{14}$

35. $0.1z-0.05=-0.07z \Rightarrow 0.17z=0.05 \Rightarrow z=\frac{0.05}{0.17} \Rightarrow z=\frac{5}{17}$ Check:
$0.1\left(\frac{5}{17}\right)-0.05=-0.07\left(\frac{5}{17}\right) \Rightarrow \frac{5}{170}-\frac{5}{100}=-\frac{35}{1700} \Rightarrow \frac{50}{1700}-\frac{85}{1700}=-\frac{35}{1700} \Rightarrow$
$-\frac{35}{1700}=-\frac{35}{1700}$

36. $1.1z-2.5=0.3(z-2) \Rightarrow 1.1z-2.5=0.3z-0.6 \Rightarrow 0.8z=1.9 \Rightarrow z=\frac{1.9}{0.8} \Rightarrow z=\frac{19}{8}$
Check: $1.1\left(\frac{19}{8}\right)-2.5=0.3\left(\frac{19}{8}-2\right) \Rightarrow \frac{209}{80}-\frac{5}{2}=\frac{3}{10}\left(\frac{3}{8}\right) \Rightarrow \frac{209}{80}-\frac{200}{80}=\frac{9}{80} \Rightarrow \frac{9}{80}=\frac{9}{80}$

37. $0.15t+0.85(100-t)=0.45(100) \Rightarrow 0.15t+85-0.85t=45 \Rightarrow -0.7t=-40 \Rightarrow t=\frac{40}{0.7} \Rightarrow$
$t=\frac{400}{7}$ Check: $0.15\left(\frac{400}{7}\right)+0.85\left(100-\frac{400}{7}\right)=0.45(100) \Rightarrow \frac{6000}{700}+85-\frac{34,000}{700}=45 \Rightarrow$
$\frac{60}{7}+85-\frac{340}{7}=45 \Rightarrow 85-\frac{280}{7}=45 \Rightarrow 85-40=45 \Rightarrow 45=45$

38. $0.35t+0.65(10-t)=0.55(10) \Rightarrow 0.35t+6.5-0.65t=5.5 \Rightarrow -0.3t=-1 \Rightarrow t=\frac{1}{0.3} \Rightarrow t=\frac{10}{3}$
Check: $0.35\left(\frac{10}{3}\right)+0.65\left(10-\frac{10}{3}\right)=0.55(10) \Rightarrow \frac{350}{300}+0.65\left(\frac{20}{3}\right)=\frac{550}{100} \Rightarrow$
$\frac{350}{300}+\frac{1300}{300}=\frac{550}{100} \Rightarrow \frac{350}{300}+\frac{1300}{300}=\frac{1650}{300} \Rightarrow \frac{1650}{300}=\frac{1650}{300}$

39. (a) $5x-1=5x+4 \Rightarrow -1=4 \Rightarrow$ there is no solution.
(b) Since no $x$-value satisfies the equation, it is contradiction.

40. (a) $7-9z=2(3-4z)-z \Rightarrow 7-9z=6-8z-z \Rightarrow 7=6 \Rightarrow$ there is no solution.
(b) Since no $x$-value satisfies the equation, it is a contradiction.

41 . (a) $3(x-1)=5 \Rightarrow 3x-3=5 \Rightarrow 3x=8 \Rightarrow x=\frac{8}{3}$
(b) Since one $x$-value is a solution and other $x$-values are not, the equation is conditional.

42. (a) $22=-2(2x+1.4) \Rightarrow 22=-4x-2.8 \Rightarrow 24.8=-4x \Rightarrow x=\frac{24.8}{-4}=-6.2$
(b) Since one $x$-value is a solution and other $x$-values are not, the equation is conditional.

43. (a) $0.5(x - 2) + 5 = 0.5x + 4 \Rightarrow 0.5x - 1 + 5 = 0.5x + 4 \Rightarrow 0.5x + 4 = 0.5x + 4 \Rightarrow$ every $x$-value satisfies this equation.

(b) Since every $x$-value satisfies the equation, it is an identity.

44. (a) $\frac{1}{2}x - 2(x - 1) = -\frac{3}{2}x + 2 \Rightarrow \frac{1}{2}x - 2x + 2 = -\frac{3}{2}x + 2 \Rightarrow 2 = 2 \Rightarrow$ every $x$-value satisfies this equation.

(b) Since every $x$-value satisfies the equation, it is an identity.

45. (a) $\frac{t + 1}{2} = \frac{3t - 2}{6} \Rightarrow 6\left(\frac{t + 1}{2} = \frac{3t - 2}{6}\right) \Rightarrow 3t + 3 = 3t - 2 \Rightarrow 3 = -2 \Rightarrow$ there is no solution.

(b) Since no $x$-value satisfies the equation, it is contradiction.

46. (a) $\frac{2x + 1}{3} = \frac{2x - 1}{3} \Rightarrow 3(2x + 1) = 3(2x - 1) \Rightarrow 6x + 3 = 6x - 3 \Rightarrow 3 = -3 \Rightarrow$ there is no solution.

(b) Since no $x$-value satisfies the equation, it is contradiction.

47. (a) $\frac{1 - 2x}{4} = \frac{3x - 1.5}{-6} \Rightarrow -6(1 - 2x) = 4(3x - 1.5) \Rightarrow -6 + 12x = 12x - 6 \Rightarrow 0 = 0 \Rightarrow$ every $x$-value satisfies this equation.

(b) Since every $x$-value satisfies the equation, it is an identity.

48. (a) $0.5(3x - 1) + 0.5x = 2x - 0.5 \Rightarrow 1.5x - 0.5 + 0.5x = 2x - 0.5 \Rightarrow 2x - 0.5 = 2x - 0.5 \Rightarrow$ every $x$-value satisfies this equation.

(b) Since every $x$-value satisfies the equation, it is an identity.

49. In the graph, the lines intersect at (3, –1). The solution is the $x$-value, 3.

50. In the graph, the lines intersect at (–5, 6). The solution is the $x$-value, $-5$.

51. (a) From the graph, when $f(x)$ or $y = -1$, $x = 4$; the solution is the $x$-value, 4.

(b) From the graph, when $f(x)$ or $y = 0$, $x = 2$; the solution is the $x$-value, 2.

(c) From the graph, when $f(x)$ or $y = 2$, $x = -2$; the solution is the $x$-value, $-2$.

52. (a) From the graph, when $f(x)$ or $y = -1$, $x = 0$; the solution is the $x$-value, 0.

(b) From the graph, when $f(x)$ or $y = 0$, $x = 1$; the solution is the $x$-value, 1.

(c) From the graph, when $f(x)$ or $y = 2$, $x = 3$; the solution is the $x$-value, 3.

53. Graph $Y_1 = X + 4$ and $Y_2 = 1 - 2X$. See Figure 53. The lines intersect at $x = -1$.

$x + 4 = 1 - 2x \Rightarrow 3 = -3x \Rightarrow x = -1$

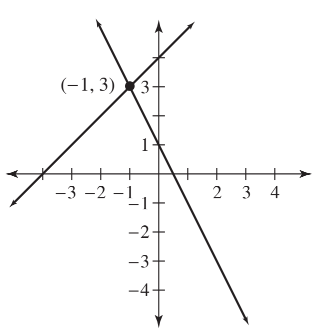



Figure 53

54. Graph $Y_1 = 2X$ and $Y_2 = 3X - 1$. See Figure 54. The lines intersect at $x = 1$.

$2x = 3x - 1 \Rightarrow -x = -1 \Rightarrow x = 1$

55. Graph $Y_1 = -X + 4$ and $Y_2 = 3X$. See Figure 55. The lines intersect at $x = 1$.

$-x + 4 = 3x \Rightarrow 4 = 4x \Rightarrow x = 1$

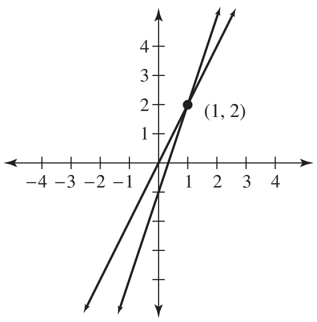



Figure 54

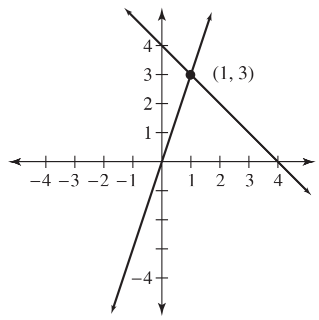



Figure 55

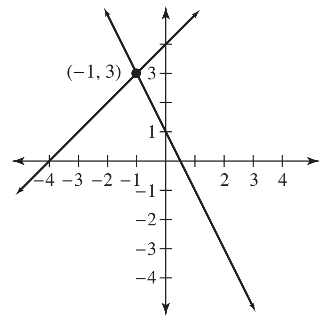



Figure 56

56. Graph $Y_1 = 1 - 2X$ and $Y_2 = X + 4$. See Figure 56. The lines intersect at $x = -1$.

$1 - 2x = x + 4 \Rightarrow -3x = 3 \Rightarrow x = -1$

57. Graph $Y_1 = 2(X - 1) - 2$ and $Y_2 = X$. See Figure 57. The lines intersect at $x = 4$.

$2(x - 1) - 2 = x \Rightarrow 2x - 2 - 2 = x \Rightarrow 2x - 4 = x \Rightarrow -4 = -x \Rightarrow x = 4$

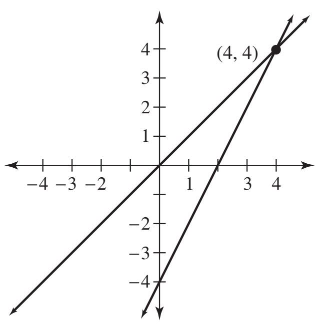



Figure 57

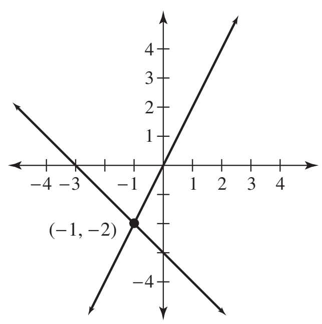



Figure 58

58. Graph $Y_1 = -(X + 1) - 2$ and $Y_2 = 2X$. The lines intersect at $x = -1$. See Figure 58.

$-(x + 1) - 2 = 2x \Rightarrow -x - 1 - 2 = 2x \Rightarrow -x - 3 = 2x \Rightarrow -3 = 3x \Rightarrow x = -1$

59. Graph $Y_1 = 5X - 1.5$ and $Y_2 = 5$. Their graphs intersect at (1.3, 5). The solution is 1.3. See Figure 59.

60. Graph $Y_1 = 8 - 2X$ and $Y_2 = 1.6$. Their graphs intersect at (3.2, 1.6). The solution is 3.2.

See Figure 60.

[–10, 10, 1] by [–10, 10, 1]

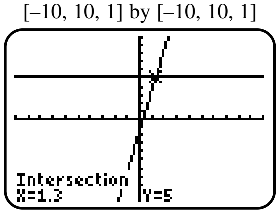



Figure 59

[–10, 10, 1] by [–10, 10, 1]

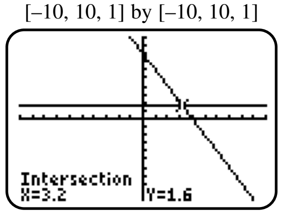



Figure 60

61. Graph $Y_1 = 3X - 1.7$ and $Y_2 = 1 - X$. Their graphs intersect at (0.675, 0.325). The solution is 0.675. See Figure 61.

[–10, 10, 1] by [–10, 10, 10]

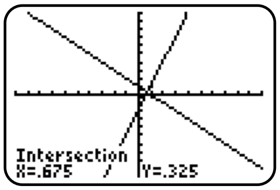



Figure 61

[–10, 10, 1] by [–10, 10, 10]

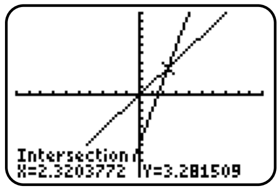



Figure 62

62. Graph $Y_1 = \sqrt{(2)}X$ and $Y_2 = 4X - 6$. Their graphs intersect near (2.320, 3.282). The solution is approximately 2.320. See Figure 62.

63. Graph $Y_1 = 3.1(X - 5)$ and $Y_2 = X/5 - 5$. Their graphs intersect near (3.621, –4.276). The solution is approximately 3.621. See Figure 63.

64. Graph $Y_1 = 65$ and $Y_2 = 8(X - 6) - 5.5$. Their graphs intersect at (14.813, 65). The solution is 14.813. See Figure 64.

[–10, 10, 1] by [–10, 10, 10]

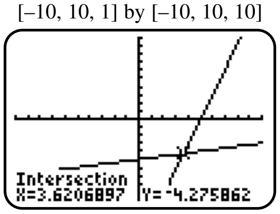



Figure 63

[–100, 100, 10] by [–100, 100, 10]

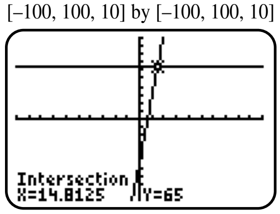



Figure 64

[–10, 10, 1] by [–10, 10, 1]

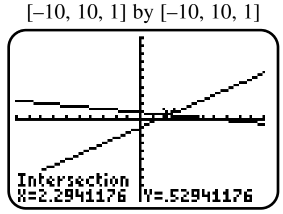



Figure 65

[–10, 10, 1] by [–10, 10, 1]

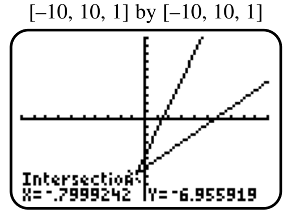



Figure 66

65. Graph $Y_1 = (6 - X)/7$ and $Y_2 = (2X - 3)/3$. Their graphs intersect near (2.294, 0.529). The solution is approximately 2.294. See Figure 65.

66. Graph $Y_1 = \pi(X - \sqrt{(2)})$ and $Y_2 = 1.07X - 6.1$. Their graphs intersect near (–0.800, –6.956). The solution is approximately $-0.800$. See Figure 66.

67. One way to solve this equation is to table $Y_1 = 2X - 7$ and determine the $x$-value where $Y_1 = -1$. See Figure 67. This occurs when $x = 3$, so the solution is 3.

68. Table $Y_1 = 1 - 6X$ and determine the $x$-value where $Y_1 = 7$. See Figure 68. This occurs when $x = -1$, so the solution is $-1$.

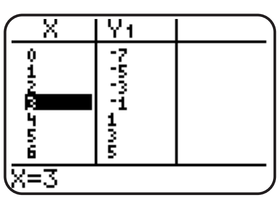



Figure 67

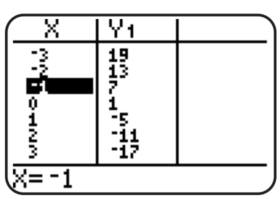



Figure 68

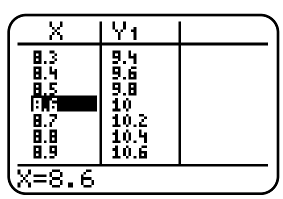



Figure 69

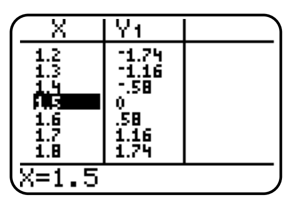



Figure 70

69. Table $Y_1 = 2X - 7.2$ and determine the $x$-value where $Y_1 = 10$. See Figure 69. This occurs when $x = 8.6$, so the solution is 8.6.

70. Table $Y_1 = 5.8X - 8.7$ and determine the $x$-value where $Y_1 = 0$. See Figure 70. This occurs when $x = 1.5$, so the solution is 1.5.

71. Table $Y_1 = \sqrt{}(2)(4X - 1) + \pi X$ and determine the $x$-value where $Y_1 = 0$. See Figure 71. This occurs when $x \approx 0.2$, so the solution is 0.2.

72. Table $Y_1 = \pi(0.3X - 2) + \sqrt{}2(X)$ and determine the $x$-value where $Y_1 = 0$. See Figure 72. This occurs when $x \approx 2.7$, so the solution is 2.7.

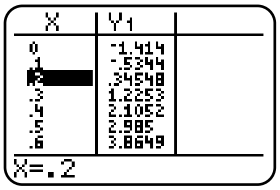


Figure 71

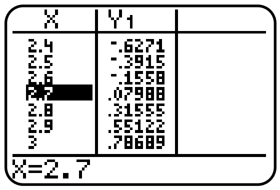


Figure 72

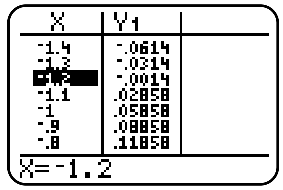


Figure 73

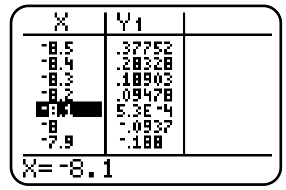


Figure 74

73. Table $Y_1 = 0.5 - 0.1(\sqrt{}(2) - 3X)$ and determine the $x$-value where $Y_1 = 0$. See Figure 73. This occurs when $x \approx -1.2$, so the solution is $-1.2$.

74. Table $Y_1 = \sqrt{}(5) - \pi(\pi + 0.3X)$ and determine the $x$-value where $Y_1 = 0$. See Figure 74. This occurs when $x \approx -8.1$, so the solution is $-8.1$.

75. (a) $5 - (x + 1) = 3 \Rightarrow 5 - x - 1 = 3 \Rightarrow 4 - x = 3 \Rightarrow x = 1$

(b) Using the intersection of graphs method, graph $Y_1 = 5 - (X + 1)$ and $Y_2 = 3$. Their point of intersection is shown in Figure 75b as (1, 3). The solution is the $x$-value, 1.

(c) Table $Y_1 = 5 - (X + 1)$ and $Y_2 = 3$. Figure 75c shows a table where $Y_1 = Y_2$ at $x = 1$.

[−10, 10, 1] by [−10, 10, 1]

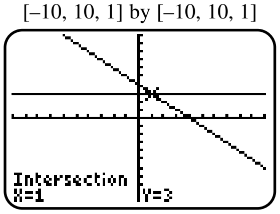


Figure 75b

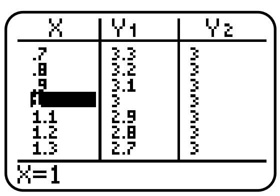


Figure 75c

[−10, 10, 1] by [−10, 10, 1]

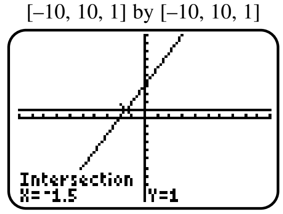


Figure 76b

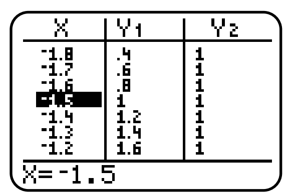


Figure 76c

76. (a) $7 - (3 - 2x) = 1 \Rightarrow 7 - 3 + 2x = 1 \Rightarrow 4 + 2x = 1 \Rightarrow x = -1.5$

(b) Using the intersection of graphs method, graph $Y_1 = 7 - (3 - 2X)$ and $Y_2 = 1$. Their point of intersection is shown in Figure 76b as $(-1.5, 1)$. The solution is the $x$-value, $-1.5$.

(c) Table $Y_1 = 7 - (3 - 2X)$ and $Y_2 = 1$. Figure 76c shows a table where $Y_1 = Y_2$ at $x = -1.5$.

77. (a) $\sqrt{3}(2 - \pi x) + x = 0 \Rightarrow 2\sqrt{3} - \sqrt{3}\pi x + x = 0 \Rightarrow -\sqrt{3}\pi x + x = -2\sqrt{3} \Rightarrow$

$$x(-\sqrt{3}\pi + 1) = -2\sqrt{3} \Rightarrow x = \frac{-2\sqrt{3}}{(-\sqrt{3}\pi + 1)} \approx 0.8.$$

(b) Using the intersection of graphs method, graph $Y_1 = \sqrt{}(3)(2 - \pi X) + X$ and $Y_2 = 0$. Their point of intersection is shown in Figure 77b as approximately (0.8, 0). The solution is the $x$-value, 0.8.

(c) Table $Y_1 = \sqrt{}(3)(2 - \pi X) + X$ and $Y_2 = 0$. Figure 77c shows a table where $Y_1 = Y_2$ at $x \approx 0.8$.

[−10, 10, 1] by [−10, 10, 1]

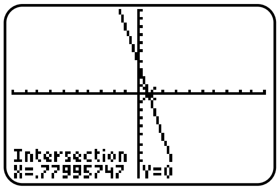



Figure 77b

| X | $Y_1$ | $Y_2$ |
|---|---|---|
| .4 | 1.6875 | 0 |
| .5 | 1.2434 | 0 |
| .6 | .79926 | 0 |
| .7 | .35512 | 0 |
| .8 | -.089 | 0 |
| .9 | -.5332 | 0 |
| 1 | -.9773 | 0 |

X=.8

Figure 77c

[−10, 10, 1] by [−10, 10, 1]

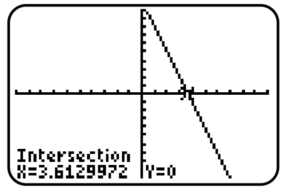



Figure 78b

| X | $Y_1$ | $Y_2$ |
|---|---|---|
| 3.4 | .63899 | 0 |
| 3.5 | .33899 | 0 |
| 3.6 | .03899 | 0 |
| 3.7 | -.261 | 0 |
| 3.8 | -.561 | 0 |
| 3.9 | -.861 | 0 |
| 4 | -1.161 | 0 |

X=3.6

Figure 78c

78. (a) $3(\pi - x) + \sqrt{2} = 0 \Rightarrow 3\pi - 3x + \sqrt{2} = 0 \Rightarrow 3\pi + \sqrt{2} = 3x \Rightarrow x = \pi + \dfrac{\sqrt{2}}{3} \approx 3.6$

(b) Using the intersection of graphs method, graph $Y_1 = 3(\pi - X) + \sqrt{(2)}$ and $Y_2 = 0$. Their point of intersection is shown in Figure 78b as approximately $(3.6, 0)$. The approximate solution is the $x$-value, 3.6.

(c) Table $Y_1 = 3(\pi - X) + \sqrt{(2)}$ and $Y_2 = 0$. Figure 78c shows a table where $Y_1 = Y_2$ at $x \approx 3.6$.

79. (a) $x - 3 = 2x + 1 \Rightarrow -x = 4 \Rightarrow x = -4$

(b) Using the intersection-of-graphs method, graph $Y_1 = X - 3$ and $Y_2 = 2X + 1$. Their point of intersection is shown in Figure 79b as $(-4, -7)$. The solution is the $x$-value, $-4$.

(c) Table $Y_1 = X - 3$ and $Y_2 = 2X + 1$, starting at $x = -7$, incrementing by 1. Figure 79c shows a table where $Y_1 = Y_2$ at $x = -4$.

[−12, 8, 1] by [−12, 8, 1]

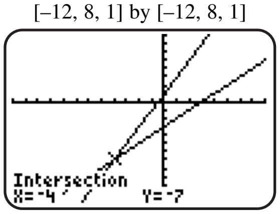



Figure 79b

| X | $Y_1$ | $Y_2$ |
|---|---|---|
| -7 | -10 | -13 |
| -6 | -9 | -11 |
| -5 | -8 | -9 |
| -4 | -7 | -7 |
| -3 | -6 | -5 |
| -2 | -5 | -3 |
| -1 | -4 | -1 |

X= -4

Figure 79c

[−10, 10, 1] by [−10, 10, 10]

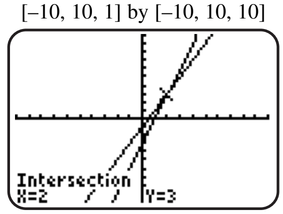



Figure 80b

| X | $Y_1$ | $Y_2$ |
|---|---|---|
| 0 | -3 | -1 |
| 1 | 0 | 1 |
| 2 | 3 | 3 |
| 3 | 6 | 5 |
| 4 | 9 | 7 |
| 5 | 12 | 9 |
| 6 | 15 | 11 |

X=2

Figure 80c

80. (a) $3(x - 1) = 2x - 1 \Rightarrow 3x - 3 = 2x - 1 \Rightarrow x = 2$

(b) Using the intersection-of-graphs method, graph $Y_1 = 3(X - 1)$ and $Y_2 = 2X - 1$. Their point of intersection is shown in Figure 80b as $(2, 3)$. The solution is the $x$-value, 2.

(c) Table $Y_1 = 3(X - 1)$ and $Y_2 = 2X - 1$, starting at $x = 0$, incrementing by 1. Figure 80c shows a table where $Y_1 = Y_2$ at $x = 2$.

81. (a) $6x - 8 = -7x + 18 \Rightarrow 13x = 26 \Rightarrow x = 2$

(b) Using the intersection-of-graphs method, graph $Y_1 = 6X - 8$ and $Y_2 = -7X + 18$. Their point of intersection is shown in Figure 81b as (2, 4). The solution is the $x$-value, 2.

(c) Table $Y_1 = 6X - 8$ and $Y_2 = -7X + 18$, starting at $x = 0$, incrementing by 1. Figure 81c shows a table where $Y_1 = Y_2$ at $x = 2$.

[−10, 10, 1] by [−10, 10, 1]

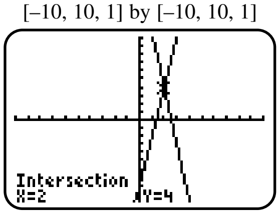



Figure 81b

| X | $Y_1$ | $Y_2$ |
|---|---|---|
| 0 | -8 | 18 |
| 1 | -2 | 11 |
| 2 | 4 | 4 |
| 3 | 10 | -3 |
| 4 | 16 | -10 |
| 5 | 22 | -17 |
| 6 | 28 | -24 |

X=2

Figure 81c

82. (a) $5 - 8x = 3(x - 7) + 37 \Rightarrow 5 - 8x = 3x - 21 + 37 \Rightarrow 5 + 21 - 37 = 3x + 8x \Rightarrow$

$-11 = 11x \Rightarrow x = -1$

(b) Using the intersection-of-graphs method, graph $Y_1 = 5 - 8X$ and $Y_2 = 3(X - 7) + 37$. Their point of intersection is shown in Figure 82b as (–1, 13). The solution is the $x$-value of $x = -1$.

(c) Table $Y_1 = 5 - 8X$ and $Y_2 = 3(X - 7) + 37$, starting at $x = -3$, incrementing by 1. Figure 82c shows a table where $Y_1 = Y_2$ at $x = -1$.

[–10, 10, 1] by [–10, 10, 1]

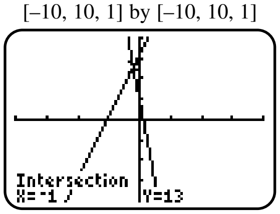



Figure 82b

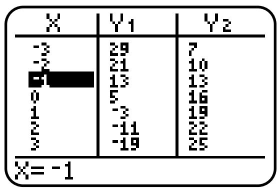



Figure 82c

[1980, 1990, 2] by [0, 200, 20]

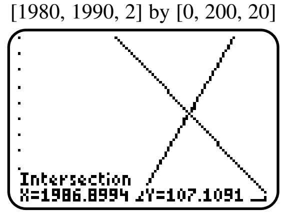



Figure 93

83. $A = LW \Rightarrow W = \dfrac{A}{L}$

84. $E = IR + 2 \Rightarrow E - 2 = IR \Rightarrow R = \dfrac{E - 2}{I}$

85. $P = 2L + 2W \Rightarrow P - 2W = 2L \Rightarrow L = \dfrac{P - 2W}{2} \Rightarrow L = \dfrac{1}{2}P - W$

86. $V = 2\pi rh + \pi r^2 \Rightarrow V - \pi r^2 = 2\pi rh \Rightarrow h = \dfrac{V - \pi r^2}{2\pi r}$

87. $3x + 2y = 8 \Rightarrow 2y = 8 - 3x \Rightarrow y = 4 - \dfrac{3}{2}x$

88. $5x - 4y = 20 \Rightarrow -4y = 20 - 5x \Rightarrow y = \dfrac{5}{4}x - 5$

89. $y = 3(x - 2) + x \Rightarrow y = 3x - 6 + x \Rightarrow y = 4x - 6 \Rightarrow 4x = y + 6 \Rightarrow x = \dfrac{1}{4}y + \dfrac{3}{2}$

90. $y = 4 - (8 - 2x) \Rightarrow y = 4 - 8 + 2x \Rightarrow y = -4 + 2x \Rightarrow 2x = y + 4 \Rightarrow x = \dfrac{1}{2}y + 2$

91. $f(x) = 19{,}000$ and $f(x) = 1000(x - 1980) + 10{,}000 \Rightarrow 1000(x - 1980) + 10{,}000 = 19{,}000 \Rightarrow$ $1000(x - 1980) = 9000 \Rightarrow x - 1980 = 9 \Rightarrow x = 1989$. The per capita income was \$19,000 in 1989.

92. $f(x) = 13{,}700$ and $f(x) = 630.8(x - 1980) + 3617 \Rightarrow 630.8(x - 1980) + 3617 = 13{,}700 \Rightarrow$

$630.8(x - 1980) = 10{,}083 \Rightarrow x - 1980 = \dfrac{10{,}083}{630.8} \Rightarrow x = 1980 + \dfrac{10{,}083}{630.8} \Rightarrow x \approx 1995.984464.$

The tuition and fees were \$13,700 in about 1996.

93. Using the intersection of graphs method, graph $Y_1 = 51.6(X - 1985) + 9.1$ and $Y_2 = -31.9(X - 1985) + 167.7$. Their approximate point of intersection is shown in Figure 93 as $(1987, 107)$. In approximately 1987 the sales of LP records and compact discs were equal.

94. $A(x) = 37$ and $A(x) = 0.07(x - 2000) + 35.3 \Rightarrow 0.07(x - 2000) + 35.3 = 37 \Rightarrow$
$0.07(x - 2000) = 1.7 \Rightarrow x - 2000 = \dfrac{1.7}{0.07} \Rightarrow x = 2000 - \dfrac{1.7}{0.07} \Rightarrow x \approx 2024$. The mediam age will reach 37 years of age in about 2024.

95. The graph of $f$ must pass through the points (1980, 64) and (2000, 80). Its slope is $m = \dfrac{80 - 64}{2000 - 1980} = 0.8$.
Thus, $f(x) = 0.8(x - 2000) + 80$. Find $x$ when $f(x) = 87 \Rightarrow 87 = 0.8(x - 2000) + 80 \Rightarrow$
$7 = 0.8(x - 2000) \Rightarrow (x - 2000) = 8.75 \Rightarrow x = 2008.75$. The US population density reached 87 people per square mile in about 2009.

96. (a) The graph of $V$ must pass through the points (1999, 180,000) and (2009, 245,000). Its slope is
$m = \dfrac{245{,}000 - 180{,}000}{2009 - 1999} = 6500$. Thus, $V(x) = 6500(x - 2009) + 245{,}000 \Rightarrow$
$V(x) = 6500x - 12{,}813{,}500$.

(b) The slope 6500 represents an increase in value of the house of $6500 per year, on average.

(c) $219{,}900 = 6500x - 12{,}813{,}500 \Rightarrow 6500x = 13{,}033{,}400 \Rightarrow x \approx 2005.14$; the approximate year was 2005.

97. To calculate the sale price subtract 25% of the regular price from the regular price.
$f(x) = x - 0.25x \Rightarrow f(x) = 0.75x$. An item which normally costs \$56.24 will be on sale for
$f(56.24) = 0.75(56.24) = \$42.18$.

98. To calculate the regular price of an item that is on sale for \$19.62, solve the equation $0.75x = 19.62$.
$0.75x = 19.62 \Rightarrow x = \dfrac{19.62}{0.75} \Rightarrow x = \$26.16$.

99. (a) The number of skin cancer cases can is given by $0.045x$.

(b) There were 65,000 cases of skin cancer diagnosed in 2007. So, $65{,}000 = 0.045x \Rightarrow x = \dfrac{65{,}000}{0.045} \Rightarrow$
$x = 1{,}444{,}000$. There were about 1,444,000 cancer cases in 2007.

100. Let $x$ be the final score on the exam. The maximum number of points possible is 500. To obtain 90% of 500 points, the following equation must be satisfied: $\dfrac{82 + 88 + 91 + x}{500} = 0.90 \Rightarrow$
$82 + 88 + 91 + x = 450 \Rightarrow x = 189$. The student must obtain a minimum score of 189 on the final exam.

101. (a) It would take a little less time than the faster gardener, who can rake the lawn alone in 3 hours. It would take both gardeners about 2 hours working together. *Answers may vary.*

(b) Let $x$ = time to rake the lawn working together. In 1 hour thge first gardener can rake $\dfrac{1}{3}$ of the lawn, whereas the second gardener can rake $\dfrac{1}{5}$ of the lawn; in $x$ hours both gardeners working together can rake $\dfrac{x}{3} + \dfrac{x}{5}$ of the lawn; $\dfrac{x}{3} + \dfrac{x}{5} = 1 \Rightarrow 5x + 3x = 15 \Rightarrow 8x = 15 \Rightarrow x = \dfrac{15}{8} = 1.875$ hours.

102. Let $x$ = time that both pumps can empty the pool together; in 1 hour the first pump can empty $\dfrac{1}{50}$ of the pool and the second pump can empty $\dfrac{1}{80}$ of the pool; in $x$ hours both pumps working together can empty $\dfrac{x}{50} + \dfrac{x}{80}$ of the pool; $\dfrac{x}{50} + \dfrac{x}{80} = 1 \Rightarrow 8x + 5x = 400 \Rightarrow 13x = 400 \Rightarrow x \approx 30.77$ hours.

103. Let $t$ = time spent traveling at 55 mph and $6 - t$ = time spent traveling at 70 mph. Using $d = rt$, we get
$d = 55t + 70(6 - t) \Rightarrow 372 = 55t + 420 - 70t \Rightarrow -48 = -15t \Rightarrow t = 3.2$ and $6 - t = 2.8$; the car traveled 3.2 hours at 55 mph and 2.8 hours at 70 mph.

104. Let $x$ = amount of the \$2.50 per pound candy and $5 - x$ = amount of the \$4.00 per pound candy; we get the equation $2.50x + 4.00(5 - x) = 17.60 \Rightarrow 250x + 400(5 - x) = 1760 \Rightarrow$ $250x + 2000 - 400x = 1760 \Rightarrow -150x = -240 \Rightarrow x = 1.6$ and $5 - x = 3.4$; add 1.6 pounds of \$2.50 candy to 3.4 pounds of \$4.00 candy.

105. Let $t$ = time traveled by car at 55 mph and $t + \frac{1}{2}$ = time traveled by runner at 10 mph; since $d = rt$ and the distance is the same for both runner and driver, we get $55t = 10\left(t + \frac{1}{2}\right) \Rightarrow 55t = 10t + 5 \Rightarrow 45t = 5 \Rightarrow$ $t = \frac{1}{9}$; it takes the driver $\frac{1}{9}$ hour or $6\frac{2}{3}$ minutes to catch the runner.

106. Let $x$ = amount invested at 5% and $5000 - x$ = amount invested at 7%;
$0.05x + 0.07(5000 - x) = 325 \Rightarrow 5x + 7(5000 - x) = 32{,}500 \Rightarrow 5x + 35{,}000 - 7x = 32{,}500 \Rightarrow$
$-2x = -2500 \Rightarrow x = 1250$ and $5000 - x = 3750$; \$1250 is invested at 5% and \$3750 is invested at 7%.

107. The follow sketch illustrates the situation, where $x$ = height of streetlight. See Figure 107.
Using similar triangles, we get $\frac{x}{15 + 7} = \frac{5.5}{7} \Rightarrow x = \frac{(5.5)(22)}{7} \Rightarrow x \approx 17.29$. The streetlight is about 17.29 feet high.

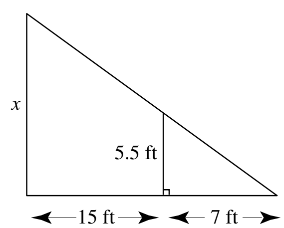



Figure 107

108. This problem can be solved using similar triangles or a proportion. Let $x$ be the height of the tree; then,
$\frac{5}{4} = \frac{x}{33} \Rightarrow x = \frac{5 \times 33}{4} = 41.25$. The height of the tree is 41.25 feet.

109. Use similar triangles to find the radius of the cone when the water is 7 feet deep: $\frac{r}{3.5} = \frac{7}{11} \Rightarrow r \approx \frac{49}{22}$ ft.
Use $V = \frac{1}{3}\pi r^2 h$ to find the volume of the water in the cone at $h = 7$ ft.: $V = \frac{1}{3}\pi\left(\frac{49}{22}\right)^2(7) \approx 36.4\text{ ft}^3$.

110. $V = \frac{1}{3}\pi r^2 h \Rightarrow 100 = \frac{1}{3}\pi(3)^2 \cdot h \Rightarrow 100 = 3\pi h \Rightarrow \frac{100}{3\pi} = h \Rightarrow h \approx 10.6$ ft.

111. Let $x$ = amount of pure water to be added and $x + 5$ = final amount of the 15% solution. Since pure water is 0% sulfuric acid, we get $0\%x + 40\%(5) = 15\%(x + 5) \Rightarrow 0.40(5) = 0.15(x + 5) \Rightarrow$
$40(5) = 15(x + 5) \Rightarrow 200 = 15x + 75 \Rightarrow 15x = 125 \Rightarrow x = \frac{125}{15} \approx 8.333$; about 8.33 liters of pure water should be added.

112. Let $x$ = gallons of 15% solution removed and amount of 65% antifreeze added.
Then $0.15(5) - 0.15x + 0.65x = 0.40(5) \Rightarrow 0.75 + 0.50x = 2 \Rightarrow 0.5x = 1.25 \Rightarrow x = 2.5$ gallons.

113. $P = 2w + 2l \Rightarrow 180 = 2w + 2(w + 18) \Rightarrow 180 = 4w + 36 \Rightarrow 4w = 144 \Rightarrow w = 36$ and $w + 18 = 54$; the window is 36 inches by 54 inches.

114. (a) The linear function $S$ must fit the coordinates (2003, 17) and (2006, 26).

$$m = \frac{26 - 17}{2006 - 2003} = 3;\ S(x) = 3(x - 2003) + 17 \Rightarrow S(x) = 3x - 5992.$$

(b) The slope shows that sales increased, on average, by \$3 billion per year.

(c) Let $S(x) = 41$ and solve for $x$. $41 = 3x - 5992 \Rightarrow 6033 = 3x \Rightarrow x = 2011$

115. (a) Using $(2002, 75)$ and $(2006, 45)$, find slope: $m = \dfrac{45 - 75}{2006 - 2002} \Rightarrow \dfrac{-30}{4} \Rightarrow -7.5$; therefore, $C(x) = -7.5(x - 2002) + 75 \Rightarrow C(x) = -7.5x + 15{,}090$. Now using $(2002, 29)$ and $(2006, 88)$, find slope: $m = \dfrac{88 - 29}{2006 - 2002} = \dfrac{59}{4} = 14.75$. Therefore, $L(x) = 14.75(x - 2002) + 29 \Rightarrow L(x) = 14.75x - 29{,}500.5$.

(b) Sales of CRT monitors decreased by 7.5 million per year, on average. Sales of LCD monitors increased by 14.75 million monitors per year, on average.

(c) Graph $C(x) = -7.5x + 15{,}090$ and $L(x) = 14.75x - 29{,}500$. See Figure 115c. The lines of the functions intersect at $x = 2004$ or year 2004.

(d) Set $L(x) = C(x)$ and solve: $14.75x - 29{,}500 = -7.5x + 15{,}090 \Rightarrow 22.25x = 44{,}590 \Rightarrow x \approx 2004$

(e) Table $Y_1 = -7.5X + 15{,}090$ and $Y_2 = 14.75X - 29{,}500$, starting at 2000, incrementing by 1. Figure 115e shows a table where $Y_1 = Y_2$ and $x = 2004$.

[2000, 2008, 1] by [0, 80, 10]

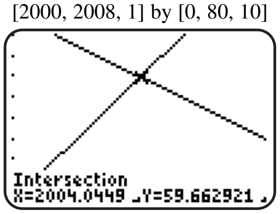


Figure 115c

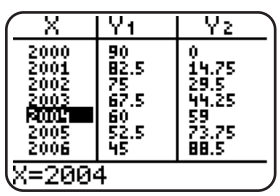


Figure 115e

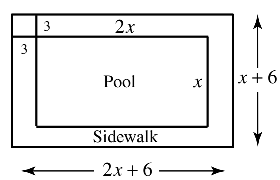


Figure 116

116. $2(x + 6) + 2(2x + 6) = 174 \Rightarrow 2x + 12 + 4x + 12 = 174 \Rightarrow 6x + 24 = 174 \Rightarrow 6x = 150 \Rightarrow x = 25 \Rightarrow 2x = 50$. The swimming pool is 25 ft by 50 ft. See Figure 116.

117. $C = \dfrac{5}{9}(F - 32)$ and $F = C \Rightarrow F = \dfrac{5}{9}(F - 32) \Rightarrow F = \dfrac{5}{9}F - \dfrac{160}{9} \Rightarrow \dfrac{4}{9}F = -\dfrac{160}{9} \Rightarrow F = -40$; $-40°\ F$ is equivalent to $-40°\ C$.

118. Let $x$ = number of copies made; the cost of producing the compact discs is given by $C(x) = 2000 + 0.45x$; $2990 = 2000 + 0.45x \Rightarrow 990 = 0.45x \Rightarrow x = 2200$; the company manufactured 2200 copies and the master disc.

119. (a) It is reasonable to expect that $f$ is linear because if the number of gallons of gas doubles so should the amount of oil. Five gallons of gasoline requires five times the oil that one gallon of gasoline would. The increase in oil is always equal to 0.16 pint for each additional gallon of gasoline. Oil is mixed at a constant rate, so a linear function describes this amount.

(b) $f(3) = 0.16(3) = 0.48$; 0.48 pint of oil should be added to 3 gallons of gasoline to get the correct mixture.

(c) $0.16x = 2 \Rightarrow x = 12.5$; 12.5 gallons of gasoline should be mixed with 2 pints of oil.

120. $P = 2w + 2l \Rightarrow 25 = 2(2x) + 2(5x - 1) \Rightarrow 25 = 4x + 10x - 2 \Rightarrow 27 = 14x \Rightarrow x = \frac{27}{14}$ ft.;

$5x - 1 = 5\left(\frac{27}{14}\right) - 1 = \frac{121}{14} \approx 8.6$ ft.

121. Linear regression gives the model:

$y = 0.36x - 0.21$. $y = 2.99 \Rightarrow 2.99 = 0.36x - 0.21 \Rightarrow 3.2 = 0.36x \Rightarrow x \approx 8.89$

122. Linear regression gives the model:

$y = 3.72x - 5.38$. $y = 2.99 \Rightarrow 2.99 = 3.72x - 5.38 \Rightarrow 8.37 = 3.72x \Rightarrow x = 2.25$

123. (a) Linear regression gives the model:

$S(x) \approx 3.974x - 14{,}479$. *Answers may vary.*

(b) $S(x) = 6 \Rightarrow 6 = 3.974x - 14.479 \Rightarrow 20.479 = 3.974x \Rightarrow x \approx 5.15$; The circumference of a finger with ring size 6 is approximately 5.15 cm.

124. (a) Linear regression gives the model:

$S(x) \approx 0.3218x - 0.0402$. *Answers may vary.*

(b) $S(x) = 7.5 \Rightarrow 7.5 = 0.3218x - 0.0402 \Rightarrow 7.5402 = 0.3218x \Rightarrow x \approx 23.4$; The circumference of a head with hat size 7.5 is approximately 23.4 in.

125. (a) Linear regression gives the model:

$f(x) \approx 0.10677x - 211.69$. *Answers may vary.*

(b) $f(1987) = 0.10677(1987) - 211.69 \Rightarrow f(1987) \approx 0.462$.

The cost of a 30-scond Super Bowl ad in 1987 was approximated to be \$0.5 million. The estimate that was found involved extrapolation.

(c) $f(x) = 3.2 \Rightarrow 3.2 = 0.10677x - 211.69 \Rightarrow 214.89 = 0.10677x \Rightarrow x \approx 2012.644$.

Thus, the cost for a 30-second Super Bowl ad could reach \$3.2 million in 2013.

126. (a) Linear regression gives the model:

$P(x) \approx 0.19573x - 369.44$. *Answers may vary.*

(b) Using $P(x) \approx 0.19573x - 369.44$, let $x = 2003$. $P(2003) = 0.19573(2003) - 369.44 \Rightarrow f(2003) \approx 22.6\%$. The percentage of women in 2003 was approximated to be 22.4%. The estimate found involved interpolation.

(c) $P(x) = 25 \Rightarrow 25 = 0.19573x - 369.44 \Rightarrow 394.44 = 0.19573x \Rightarrow x \approx 2015.22$.

Thus, the percentage could reach 25% in 2015.

## Extended and Discovery Exercises for Section 2.3

1. (a) Yes; since multiplication distributes over addition, doubling the lengths gives double the sum of the lengths.
   (b) No; If the length and width are doubled, the product of the length and width is multiplied by 4.
2. If each side of a figure is doubled, then the perimeter of the larger figure is twice the perimeter of the original figure, and the area of the larger figure will be four times the area of the original figure; if the radius of a circle is doubled, then the larger circle will have twice the circumference and four times the area of the original circle.
3. (a) $(100 \text{ ft}^2)(140\ \mu\text{g/ft}^2) = 14{,}000\ \mu\text{g}$; $f(x) = 14{,}000x$.
   (b) $(800 \text{ ft}^3)(33\mu\text{g/ft}^3) = 26{,}400\ \mu\text{g}$; $f(x) = 14{,}000x \Rightarrow 26{,}400 = 14{,}000x \Rightarrow x \approx 1.9$; it takes about 1.9 hours for the concentrations to reach 33 $\mu\text{g/ft}^3$.
4. (a) See Figure 4.
   (b) Using the data points (0, 30) and (25, 32.7), we get $m = \dfrac{32.7 - 30}{25 - 0} = \dfrac{2.7}{25} = 0.108$; the point $(0, 30) \Rightarrow b = 30$; $f(x) = mx + b \Rightarrow f(x) = 0.108x + 30$.
   (c) $f(65) = 0.108(65) + 30 = 37.02$; when the temperature is 65ºC, the volume of the gas is 37.02 $\text{in}^3$.
   (d) Let $f(x) = 25$, then $25 = 0.108x + 30 \Rightarrow -5 = 0.108x \Rightarrow x \approx -46.3$. The answer was found using extrapolation. The answer is accurate because of the ideal gas laws. *Answers may vary.*

[–5, 125, 25] by [0, 50, 10]

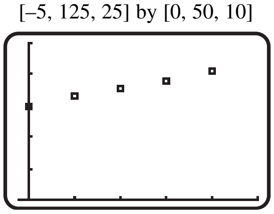


Figure 4

## 2.4: Linear Inequalities

1. $(-\infty, 2)$
2. $(-3, \infty)$
3. $[-1, \infty)$
4. $[\infty, 7]$
5. $[1, 8)$
6. $(-2, 4]$
7. $(-\infty, 1]$
8. $(5, \infty)$
9. $2x + 6 \geq 10 \Rightarrow 2x \geq 4 \Rightarrow x \geq 2$; $[2, \infty)$; set-builder notation the interval is $\{x \mid x \geq 2\}$.
10. $-4x - 3 < 5 \Rightarrow -4x < 8 \Rightarrow x > -2$; $(-2, \infty)$; set-builder notation the interval is $\{x \mid x > -2\}$.
11. $-2(x - 10) + 1 > 0 \Rightarrow -2x + 21 > 0 \Rightarrow -2x > -21 \Rightarrow x < 10.5$; $(-\infty, 10.5)$; set-builder notation the interval is $\{x \mid x < 10.5\}$.

12. $3(x + 5) \le 0 \Rightarrow x + 5 \le 0 \Rightarrow x \le -5$; $(-\infty, -5]$; set-builder notation the interval is $\{x \mid x \le -5\}$.

13. $\frac{t + 2}{3} \ge 5 \Rightarrow t + 2 \ge 15 \Rightarrow t \ge 13$; $[13, \infty)$; set-builder notation the interval is $\{t \mid t \ge 13\}$.

14. $\frac{2 - t}{6} < 0 \Rightarrow 2 - t < 0 \Rightarrow 2 < t$; $(2, \infty)$; set-builder notation the interval is $\{t \mid t > 2\}$.

15. $4x - 1 < \frac{3 - x}{-3} = 7 \Rightarrow -12x + 3 > 3 - x \Rightarrow -11x > 0 \Rightarrow x < 0$; $(-\infty, 0)$; set-builder notation the interval is $\{x \mid x < 0\}$.

16. $\frac{x + 5}{-10} > 2x + 3 \Rightarrow x + 5 < -20x - 30 \Rightarrow 21x < -35 \Rightarrow x < -\frac{5}{3}$; $\left(-\infty, -\frac{5}{3}\right)$; set-builder notation the interval is $\left\{x \mid x < -\frac{5}{3}\right\}$.

17. $-3(z - 4) \ge 2(1 - 2z) \Rightarrow -3z + 12 \ge 2 - 4z \Rightarrow z \ge -10$; $[-10, \infty)$; set-builder notation the interval is $\{z \mid z \ge -10\}$.

18. $-\frac{1}{4}(2z - 6) + z \ge 5 \Rightarrow -\frac{1}{2}z + \frac{3}{2} + z \ge 5 \Rightarrow \frac{1}{2}z \ge \frac{7}{2} \Rightarrow z \ge 7$; $[7, \infty)$; set-builder notation the interval is $\{z \mid z \ge 7\}$.

19. $\frac{1 - x}{4} < \frac{2x - 2}{3} \Rightarrow 3(1 - x) < 4(2x - 2) \Rightarrow 3 - 3x < 8x - 8 \Rightarrow -11x < -11 \Rightarrow x > 1$; $(1, \infty)$; set-builder notation the interval is $\{x \mid x > 1\}$.

20. $\frac{3x}{4} < x - \frac{x + 2}{2} \Rightarrow 3x < 4x - 2(x + 2) \Rightarrow 3x < 2x - 4 \Rightarrow x < -4$; $(-\infty, -4)$; set-builder notation the interval is $\{x \mid x < -4\}$.

21. $2x - 3 > \frac{1}{2}(x + 1) \Rightarrow 2x - 3 > \frac{1}{2}x + \frac{1}{2} \Rightarrow \frac{3}{2}x > \frac{7}{2} \Rightarrow x > \frac{7}{3}$; $\left(\frac{7}{3}, \infty\right)$; set-builder notation the interval is $\left\{x \mid x > \frac{7}{3}\right\}$.

22. $5 - (2 - 3x) \le -5x \Rightarrow 5 - 2 + 3x \le -5x \Rightarrow 8x \le -3 \Rightarrow x \le -\frac{3}{8}$; $\left(-\infty, -\frac{3}{8}\right]$; set-builder notation the interval is $\left\{x \mid x \le -\frac{3}{8}\right\}$.

23. $5 < 4t - 1 \le 11 \Rightarrow 6 < 4t \le 12 \Rightarrow \frac{3}{2} < t \le 3$; $\left(\frac{3}{2}, 3\right]$; set-builder notation the interval is $\left\{t \mid \frac{3}{2} < t \le 3\right\}$.

24. $-1 \le 2t \le 4 \Rightarrow -\frac{1}{2} \le t \le 2$; $\left[-\frac{1}{2}, 2\right]$; set-builder notation the interval is $\left\{t \mid -\frac{1}{2} \le t \le 2\right\}$.

25. $3 \le 4 - x \le 20 \Rightarrow -1 \le -x \le 16 \Rightarrow 1 \ge x \ge -16$; $[-16, 1]$; set-builder notation the interval is $\{x \mid -16 \le x \le 1\}$.

26. $-5 < 1 - 2x < 40 \Rightarrow -6 < -2x < 39 \Rightarrow 3 > x > -19.5$; $(-19.5, 3)$; set-builder notation the interval is $\{x \mid -19.5 < x < 3\}$.

27. $-7 \le \frac{1-4x}{7} < 12 \Rightarrow -49 \le 1 - 4x < 84 \Rightarrow -50 \le -4x < 83 \Rightarrow 12.5 \ge x > -20.75;$ $(-20.75, 12.5]$; set-builder notation the interval is $\{x \mid -20.75 < x \le 12.5\}$.

28. $0 < \frac{7x-5}{3} \le 4 \Rightarrow 0 < 7x - 5 \le 12 \Rightarrow 5 < 7x \le 17 \Rightarrow \frac{5}{7} < x \le \frac{17}{7}$; $\left(\frac{5}{7}, \frac{17}{7}\right]$; set-builder notation the interval is $\left\{x \mid \frac{5}{7} < x \le \frac{17}{7}\right\}$.

29. $5 > 2(x+4) - 5 > -5 \Rightarrow 5 > 2x + 8 - 5 > -5 \Rightarrow 2 > 2x > -8 \Rightarrow 1 > x > -4$; $(-4, 1)$; set-builder notation the interval is $\{x \mid -4 < x < 1\}$.

30. $\frac{8}{3} \ge \frac{4}{3} - (x+3) \ge \frac{2}{3} \Rightarrow 8 \ge 4 - 3(x+3) \ge 2 \Rightarrow 8 \ge 4 - 3x - 9 \ge 2 \Rightarrow 13 \ge -3x \ge 7 \Rightarrow$ $-\frac{13}{3} \le x \le -\frac{7}{3}$; $\left[-\frac{13}{3}, -\frac{7}{3}\right]$; set-builder notation the interval is $\left\{x \mid -\frac{13}{3} \le x \le -\frac{7}{3}\right\}$.

31. $3 \le \frac{1}{2}x + \frac{3}{4} \le 6 \Rightarrow 12 \le 2x + 3 \le 24 \Rightarrow 9 \le 2x \le 21 \Rightarrow \frac{9}{2} \le x \le \frac{21}{2}$; $\left[\frac{9}{2}, \frac{21}{2}\right]$; set-builder notation the interval is $\left\{x \mid \frac{9}{2} \le x \le \frac{21}{2}\right\}$.

32. $-4 \le 5 - \frac{4}{5}x < 6 \Rightarrow -20 \le 25 - 4x < 30 \Rightarrow -45 \le -4x < 5 \Rightarrow \frac{45}{4} \ge x > -\frac{5}{4}$; $(-1.25, 11.25]$; set-builder notation the interval is $\{x \mid -1.25 < x \le 11.25\}$.

33. $5x - 2(x+3) \ge 4 - 3x \Rightarrow 5x - 2x - 6 \ge 4 - 3x \Rightarrow 6x \ge 10 \Rightarrow x \ge \frac{5}{3}$; $\left[\frac{5}{3}, \infty\right)$; set-builder notation the interval is $\left\{x \mid x \ge \frac{5}{3}\right\}$.

34. $3x - 1 < 2(x-3) + 1 \Rightarrow 3x - 1 < 2x - 6 + 1 \Rightarrow x < -4$; $(-\infty, -4)$; set-builder notation the interval is $\{x \mid x < -4\}$.

35. $\frac{1}{2} \le \frac{1-2t}{3} < \frac{2}{3} \Rightarrow \frac{3}{2} \le 1 - 2t < 2 \Rightarrow \frac{1}{2} \le -2t < 1 \Rightarrow -\frac{1}{4} \ge t > -\frac{1}{2} \Rightarrow -\frac{1}{2} < t \le -\frac{1}{4}$; $\left(-\frac{1}{2}, -\frac{1}{4}\right]$; set-builder notation the interval is $\left\{t \mid -\frac{1}{2} < t \le -\frac{1}{4}\right\}$.

36. $-\frac{3}{4} < \frac{2-t}{5} < \frac{3}{4} \Rightarrow -\frac{15}{4} < 2 - t < \frac{15}{4} \Rightarrow -\frac{23}{4} < -t < \frac{7}{4} \Rightarrow \frac{23}{4} > t > -\frac{7}{4} \Rightarrow -\frac{7}{4} < t < \frac{23}{4}$; $\left(-\frac{7}{4}, \frac{23}{4}\right)$; set-builder notation the interval is $\left\{t \mid -\frac{7}{4} < t < \frac{23}{4}\right\}$.

37. $\frac{1}{2}z + \frac{2}{3}(3 - z) - \frac{5}{4}z \ge \frac{3}{4}(z - 2) + z \Rightarrow \frac{1}{2}z + 2 - \frac{2}{3}z - \frac{5}{4}z \ge \frac{3}{4}z - \frac{3}{2} + z \Rightarrow$ $-\frac{17}{12}z + 2 \ge \frac{7}{4}z - \frac{3}{2} \Rightarrow -\frac{38}{12}z \ge -\frac{7}{2} \Rightarrow z \le \frac{21}{19}$; $\left(-\infty, \frac{21}{19}\right]$; set-builder notation the interval is $\left\{z \mid z \le \frac{21}{19}\right\}$.

38. $\frac{2}{3}(1 - 2z) - \frac{3}{2}z + \frac{5}{6}z \geq \frac{2z - 1}{3} + 1 \Rightarrow \frac{2}{3} - \frac{4}{3}z - \frac{3}{2}z + \frac{5}{6}z \geq \frac{2z - 1}{3} + 1 \Rightarrow$
$2 - 4z - \frac{9}{2}z + \frac{5}{2}z \geq 2z - 1 + 3 \Rightarrow -6z + 2 \geq 2z + 2 \Rightarrow 0 \geq 8z \Rightarrow z \leq 0;\ (-\infty, 0);$ set-builder notation the interval is $\{x \mid x \leq 0\}$.

39. Graph $y_1 = x + 2$ and $y_2 = 2x$. See Figure 39. $y_1 \geq y_2$ when the graph of $y_1$ is above the graph of $y_2$, which is left of the intersection point $(2, 4)$ and includes point $(2, 4) \Rightarrow \{x \mid x \leq 2\}$.

40. Graph $y_1 = 2x - 1$ and $y_2 = x$. See Figure 40. $y_1 \leq y_2$ when the graph of $y_1$ is below the graph of $y_2$, which is left of the intersection point $(1, 1)$ and includes point $(1, 1) \Rightarrow \{x \mid x \leq 1\}$.

[–10, 10, 1] by [–10, 10, 1]

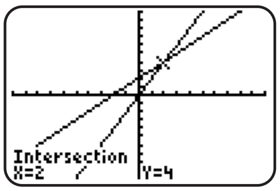



Figure 39

[–10, 10, 1] by [–10, 10, 1]

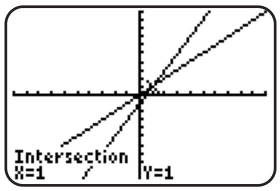



Figure 40

[–10, 10, 1] by [–10, 10, 1]

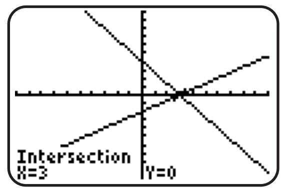



Figure 41

[–10, 10, 1] by [–10, 10, 1]

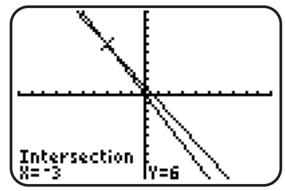



Figure 42

41. Graph $y_1 = \frac{2}{3}x - 2$ and $y_2 = -\frac{4}{3}x + 4$. See Figure 41. $y_1 > y_2$ when the graph of $y_1$ is above the graph of $y_2$, which is right of the intersection point $(3, 0)$ and does not include point $(3, 0) \Rightarrow \{x \mid x > 3\}$.

42. Graph $y_1 = -2x$ and $y_2 = -\frac{5}{3}x + 1$. See Figure 42. $y_1 \geq y_2$ when the graph of $y_1$ is above the graph of $y_2$, which is left of the intersection point $(-3, 6)$ and includes point $(-3, 6) \Rightarrow \{x \mid x \leq -3\}$.

43. Graph $y_1 = -1$, $y_2 = 2x - 1$, and $y_3 = 3$. See Figure 43. $y_1 \leq y_2 \leq y_3$ when the graph of $y_2$ is in between the graphs of $y_1$ and $y_3$, which is in between the intersection points $(0, -1)$ and $(2, 3)$ and it does include each point $\Rightarrow \{x \mid 0 \leq x \leq 2\}$.

44. Graph $y_1 = -2$, $y_2 = 1 - x$, and $y_3 = 2$. See Figure 44. $y_1 < y_2 < y_3$ when the graph of $y_2$ is in between the graphs of $y_1$ and $y_3$, which is in between the intersection points $(-1, 2)$ and $(3, -2)$ and it does not include each point $\Rightarrow \{x \mid -1 < x < 3\}$.

[–10, 10, 1] by [–10, 10, 1]

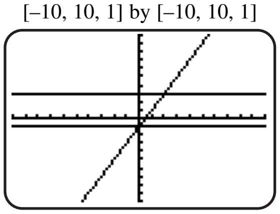


Figure 43

[–10, 10, 1] by [–10, 10, 1]

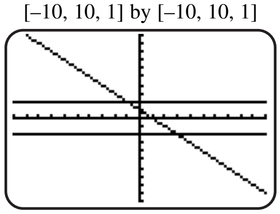


Figure 44

[–10, 10, 1] by [–10, 10, 1]

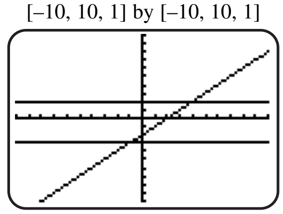


Figure 45

[–10, 10, 1] by [–10, 10, 1]

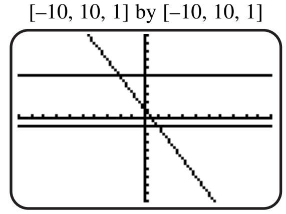


Figure 46

45. Graph $y_1 = -3$, $y_2 = x - 2$, and $y_3 = 2$. See Figure 45. $y_1 < y_2 \leq y_3$ when the graph of $y_2$ is in between the graphs of $y_1$ and $y_3$, which is in between the intersection points $(-1, -3)$ and $(4, 2)$ and it does not include the point $(-1, -3)$ but does include $(4, 2) \Rightarrow \{x \mid -1 < x \leq 4\}$.

46. Graph $y_1 = -1$, $y_2 = 1 - 2x$, and $y_3 = 5$. See Figure 46. $y_1 \leq y_2 < y_3$ when the graph of $y_2$ is in between the graphs of $y_1$ and $y_3$, which is in between the intersection points $(-2, 5)$ and $(1, -1)$ and it does not include $(-2, 5)$ and does include $(1, -1) \Rightarrow \{x \mid -2 < x \leq 1\}$.

47. (a) $y = \frac{3}{2}x - 3$, then $ax + b = 0$ gives us $\frac{3}{2}x - 3 = 0 \Rightarrow \frac{3}{2}x = 3 \Rightarrow x = 2$

(b) $ax + b < 0$ gives us $\frac{3}{2}x - 3 < 0 \Rightarrow x < 2 \Rightarrow (-\infty, 2)$ or in set builder notation, $\{x \mid x < 2\}$.

(c) $ax + b \geq 0$ gives us $\frac{3}{2}x - 3 \geq 0 \Rightarrow x \geq 2 \Rightarrow [2, \infty)$ or in set builder notation, $\{x \mid x \geq 2\}$.

48. (a) $y = -x + 1$, then $ax + b = 0$ gives us $-x + 1 = 0 \Rightarrow -x = -1 \Rightarrow x = 1$

(b) $ax + b < 0$ gives us $-x + 1 < 0 \Rightarrow x > 1 \Rightarrow (1, \infty)$ or in set builder notation, $\{x \mid x > 1\}$.

(c) $ax + b \geq 0$ gives us $-x + 1 \geq 0 \Rightarrow x \leq 1 \Rightarrow (-\infty, 1]$ or in set builder notation, $\{x \mid x \leq 1\}$.

49. (a) $y = -x - 2$, then $ax + b = 0$ gives us $-x - 2 = 0 \Rightarrow -x = 2 \Rightarrow x = -2$

(b) $ax + b < 0$ gives us $-x - 2 < 0 \Rightarrow x > -2 \Rightarrow (-2, \infty)$ or in set builder notation, $\{x \mid x > -2\}$.

(c) $ax + b \geq 0$ gives us $-x - 2 \geq 0 \Rightarrow x \leq -2 \Rightarrow (-\infty, -2]$ or in set builder notation, $\{x \mid x \leq -2\}$.

50. (a) $y = 3x + 3$, then $ax + b = 0$ gives us $3x + 3 = 0 \Rightarrow 3x = -3 \Rightarrow x = -1$

(b) $ax + b < 0$ gives us $3x + 3 < 0 \Rightarrow x < -1 \Rightarrow (-\infty, -1)$ or in set builder notation, $\{x \mid x < -1\}$.

(c) $ax + b \geq 0$ gives us $3x + 3 \geq 0 \Rightarrow x \geq -1 \Rightarrow [-1, \infty)$ or in set builder notation, $\{x \mid x \geq -1\}$.

51. $x - 3 \leq \frac{1}{2}x - 2 \Rightarrow x - 3 - \frac{1}{2}x + 2 \leq 0 \Rightarrow \frac{1}{2}x - 1 \leq 0$. Figure 51 shows the graph of $y_1 = \frac{1}{2}x - 1$. The solution set for $y_1 \leq 0$ occurs when the graph is on or below the $x$-axis, or when $x \leq 2$. The solution set is $(-\infty, 2]$. Solving symbolically, $x - 3 \leq \frac{1}{2}x - 2 \Rightarrow \frac{1}{2}x \leq 1 \Rightarrow x \leq 2 \Rightarrow$ $(-\infty, 2]$. In set-builder notation the interval is $\{x \mid x \leq 2\}$.

52. $x - 2 \leq \frac{1}{3}x \Rightarrow x - 2 - \frac{1}{3}x \leq 0 \Rightarrow \frac{2}{3}x - 2 \leq 0$. Figure 52 shows the graph of $y_1 = \frac{2}{3}x - 2$. The solution set for $y_1 \leq 0$ occurs when the graph is on or below the $x$-axis, or when $x \leq 3$. The solution set is $(-\infty, 3]$. Solving symbolically, $x - 2 \leq \frac{1}{3}x \Rightarrow \frac{2}{3}x \leq 2 \Rightarrow x \leq 3 \Rightarrow (-\infty, 3]$. In set-builder notation the interval is $\{x \mid x \leq 3\}$.

[–10, 10, 1] by [–10, 10, 1]

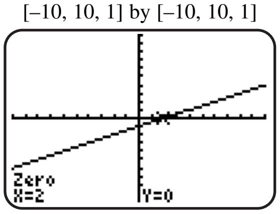



Figure 51

[–10, 10, 1] by [–10, 10, 1]

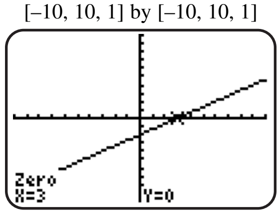



Figure 52

[–10, 10, 1] by [–10, 10, 1]

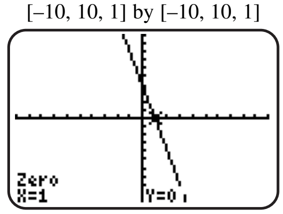



Figure 53

[–10, 10, 1] by [–10, 10, 1]

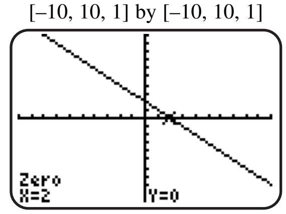



Figure 54

53. $2 - x < 3x - 2 \Rightarrow 2 - x - 2x + 2 < 0 \Rightarrow -4x + 4 < 0$. Figure 53 shows the graph of $y_1 = -4x + 4$. The solution set for $y_1 < 0$ occurs when the graph is below the $x$-axis, or when $x > 1$. The solution set is $(1, \infty)$. Solving symbolically, $2 - x < 3x - 2 \Rightarrow -4x < -4 \Rightarrow x > 1 \Rightarrow (1, \infty)$. In set-builder notation the interval is $\{x \mid x > 1\}$.

54. $\frac{1}{2}x + 1 > \frac{3}{2}x - 1 \Rightarrow \frac{1}{2}x + 1 - \frac{3}{2}x + 1 > 0 \Rightarrow -x + 2 > 0$. Figure 54 shows the graph of $y_1 = -x + 2$. The solution set for $y_1 > 0$ occurs when the graph is above the $x$-axis, or when $x < 2$. The solution set is $(-\infty, 2)$. Solving symbolically, $\frac{1}{2}x + 1 > \frac{3}{2}x - 1 \Rightarrow -x > -2 \Rightarrow x < 2 \Rightarrow (-\infty, 2)$. In set-builder notation the interval is $\{x \mid x \leq 2\}$.

55. Graph $Y_1 = 5X - 4$ and $Y_2 = 10$. The graphs intersect at the point (2.8, 10). The graph of $Y_1$ is above the graph of $Y_2$ for $x$-values to the right of this intersection point or where $x > 2.8$, $\{x \mid x > 2.8\}$. See Figure 55.

56. Graph $Y_1 = -3X + 6$ and $Y_2 = 9$. The graphs intersect at the point (–1, 9). The graph of $Y_1$ is below the graph of $Y_2$ for $x$-values to the right of this intersection point, so $y_1 \leq y_2$ when $x \geq -1$, $\{x \mid x \geq -1\}$. See Figure 56.

[–15, 15, 2] by [–15, 15, 2]

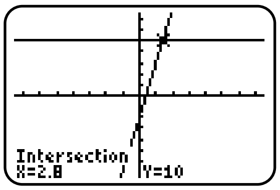



Figure 55

[–10, 10, 1] by [–10, 10, 1]

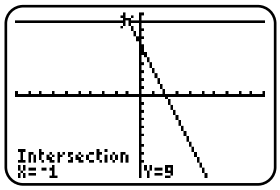



Figure 56

[1980, 2000, 1] by [0, 100, 10]

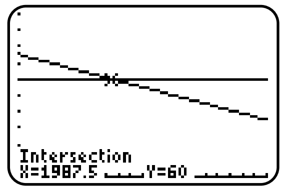



Figure 57

[–3, 3, 1] by [–2, 2, 1]

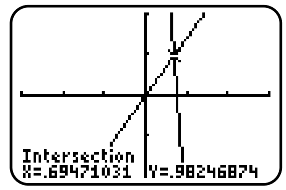



Figure 58

57. Graph $Y_1 = -2(X - 1990) + 55$ and $Y_2 = 60$. The graphs intersect at the point (1987.5, 60). The graph of $Y_1$ is above the graph of $Y_2$ for $x$-values to the left of this intersection point, so $y_1 \geq y_2$ when $x \leq 1987.5$, $\{x \mid x \leq 1987.5\}$. See Figure 57.

58. Graph $Y_1 = \sqrt{(2)}X$ and $Y_2 = 10.5 - 13.7X$. The graphs intersect near the point (0.6947, 0.9825). The graph of $Y_1$ is above the graph of $Y_2$ for $x$-values to the right of this intersection point or when $x > k$, where $k \approx 0.69$, $\{x \mid x > 0.69\}$. See Figure 58.

59. Graph $Y_1 = \sqrt{(5)}(X - 1.2) - \sqrt{(3)}X$ and $Y_2 = 5(X + 1.1)$. The graphs intersect near the point (–1.820, –3.601). The graph of $Y_1$ is below the graph of $Y_2$ for $x$-values to the right of this intersection point or when $x > k$, where $k \approx -1.82$, $\{x \mid x > -1.82\}$. See Figure 59.

60. Graph $Y_1 = 1.238X + 0.998$ and $Y_2 = 1.23(3.987 - 2.1X)$. The graphs intersect near the point (1.022, 2.264). The graph of $Y_1$ is below the graph of $Y_2$ for $x$-values to the left of this intersection point, so $y_1 \leq y_2$ when $x \leq k$, where $k \approx 1.02$, $\{x \mid x \leq 1.02\}$. See Figure 60.

[–10, 10, 1] by [–10, 10, 1]

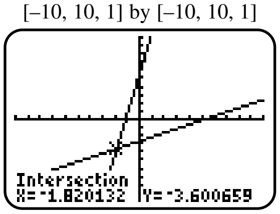



Figure 59

[–10, 10, 1] by [–10, 10, 1]

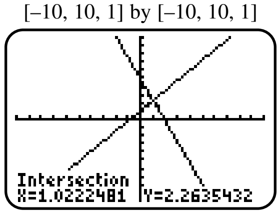



Figure 60

[–5, 15, 5] by [–5, 20, 5]

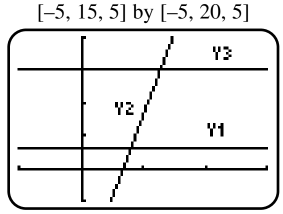



Figure 61

[–20, 40, 10] by [–10, 20, 10]

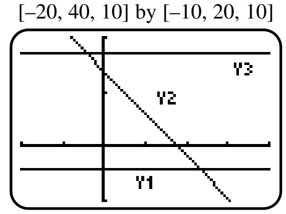



Figure 62

61. Graph $Y_1 = 3$, $Y_2 = 5X - 17$ and $Y_3 = 15$, as shown in Figure 61. The graphs intersect at the points (4, 3) and (6.4, 15). The solutions to $Y_1 \leq Y_2 < Y_3$ are the $x$-values between 4 and 6.4, including 4 $\Rightarrow [4, 6.4)$. In set-builder notation the interval is $\{x \mid 4 \leq x < 6.4\}$.

62. Graph $Y_1 = -4$, $Y_2 = (55 - 3.1X)/4$ and $Y_3 = 17$, as shown in Figure 62. The graphs intersect near the points (22.9, –4) and (–4.2, 17). The solutions to $Y_1 < Y_2 < Y_3$ are the $x$-values between $-4.2$ and 22.9 or $-4.2 < x < 22.9 \Rightarrow (-4.2, 22.9)$ (approximate). In set-builder notation the interval is $\{x \mid -4.2 < x < 22.9\}$.

63. Graph $Y_1 = 1.5$, $Y_2 = 9.1 - 0.5X$ and $Y_3 = 6.8$, as shown in Figure 63. The graphs intersect at the points (4.6, 6.8) and (15.2, 1.5). The solutions to $Y_1 \le Y_2 \le Y_3$ are the $x$-values between 4.6 and 15.2 (inclusive) or $4.6 \le x \le 15.2 \Rightarrow [4.6, 15.2]$. In set builder notation the interval is $\{x \mid 4.6 \le x \le 15.2\}$.

64. Graph $Y_1 = 0.2X$, $Y_2 = (2X - 5)/3$ and $Y_3 = 8$, as shown in Figure 64. The graph of $y_2$ intersects the graphs of $y_1$ and $y_3$ near (3.571, 0.7143) and at (14.5, 8). The solutions to $Y_1 < Y_2 < Y_3$ are the $x$-values between 3.6 and 14.5 or $3.6 < x < 14.5 \Rightarrow (3.6, 14.5)$ (approximate). In set-builder notation the interval is $\{x \mid 3.6 < x < 4.5\}$.

[0, 30, 1] by [–5, 15, 1]

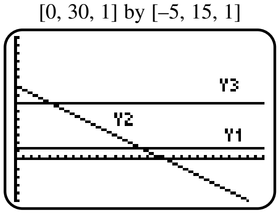



Figure 63

[–10, 20, 5] by [–5, 15, 5]

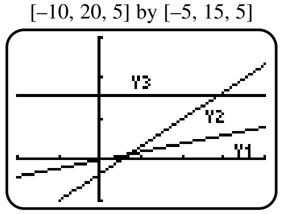



Figure 64

[–10, 15, 5] by [–10, 10, 1]

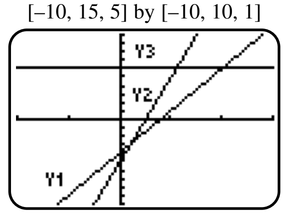



Figure 65

[–5, 5, 1] by [–5, 5, 1]

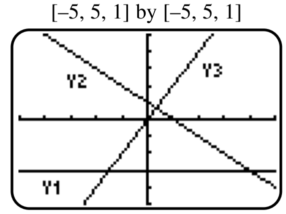



Figure 66

65. Graph $Y_1 = X - 4$, $Y_2 = 2X - 5$ and $Y_3 = 6$, as shown in Figure 65. The graph of $y_2$ intersects the graphs of $y_1$ and $y_3$ at (1, –3) and (5.5, 6). The solutions to $Y_1 < Y_2 < Y_3$ are the $x$-values between 1 and 5.5 or $1 < x < 5.5 \Rightarrow (1, 5.5)$. In set-builder notation the interval is $\{x \mid 1 < x < 5.5\}$.

66. Graph $Y_1 = -3$, $Y_2 = 1 - X$ and $Y_3 = 2X$, as shown in Figure 66. The graph of $y_2$ intersects the graphs of $y_1$ and $y_3$ near (0.3333, 0.6667) and at (4, –3). The solutions to $Y_1 \le Y_2 \le Y_3$ are the $x$-values between 0.33 and 4 (inclusive) or $0.33 \le x \le 4 \Rightarrow [0.33, 4]$ (approximate). In set-builder notation the interval is $\{x \mid 0.33 \le x \le 4\}$.

67. (a) The graphs intersect at the point (8, 7). Therefore, $g(x) = f(x)$ is satisfied when $x = 8$. The solution is 8.

    (b) $g(x) > f(x)$ whenever the $y$-values on the graph of $g$ are above the $y$-values on the graph of $f$. This occurs to the left of the point of intersection. Therefore the $x$-values that satisfy this inequality are $x < 8$. In set-builder notation the interval is $\{x \mid x < 8\}$.

68. (a) $f(x) = g(x)$ when $x = 4$ since their graphs intersect at (4, 200). The solution is 4.

    (b) $g(x) = h(x)$ when $x = 2$ since their graphs intersect at (2, 400). The solution is 2.

    (c) $f(x) < g(x) < h(x)$ when $2 < x < 4$. In set-builder notation the interval is $\{x \mid 2 < x < 4\}$.

    (d) $g(x) > h(x)$ when $0 \le x < 2$. In set-builder notation the interval is $\{x \mid 0 \le x < 2\}$.

69. From the table,

    $Y_1 = 0$ when $x = 4$. $Y_1 > 0$ when $x < 4 \Rightarrow \{x \mid x < 4\}$; $Y_1 \le 0$ when $x \ge 4 \Rightarrow \{x \mid x \ge 4\}$.

70. From the table, $Y_1 = 0$ when $x = -3$. $Y_1 < 0$ when $x < -3$ and $Y_1 \ge 0$ when $x \ge -3 \Rightarrow$ $\{x \mid x < -3\}$; $\{x \mid x \ge -3\}$.

71. Let $Y_1 = -4X - 6$. From the table shown in Figure 71, $Y_1 = 0$ when $x = -1.5$ or $-\frac{3}{2}$. $Y_1 > 0$ when $x < -\frac{3}{2}$. In set-builder notation the interval is $\left\{x \mid x < -\frac{3}{2}\right\}$.

72. Let $Y_1 = 1 - 2X$. From the table shown in Figure 72, $Y_1 = 9$ when $x = -4$. $Y_1 \geq 9$ when $x \leq -4 \Rightarrow (-\infty, -4]$. In set builder notation the interval is $\{x \mid x \leq -4\}$.

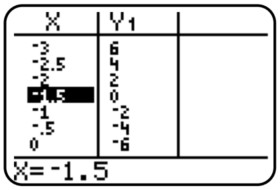


Figure 71

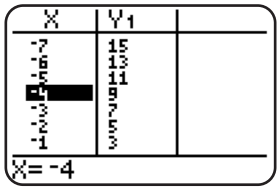


Figure 72

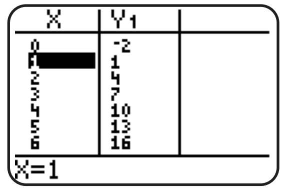


Figure 73

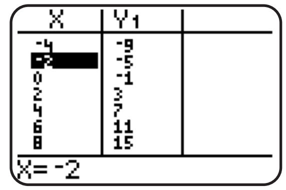


Figure 74

73. Let $Y_1 = 3X - 2$. From the table shown in Figure 73, $Y_1$ is between 10 and 4 (inclusive) for $x$-values between 1 and 4 (inclusive) $\Rightarrow [1, 4]$. In set-builder notation the interval is $\{x \mid 1 \leq x \leq 4\}$.

74. Let $Y_1 = 2X - 1$. From the table shown in Figure 74, $Y_1$ is between $-5$ and 15 for $x$-values between $-2$ and 8 $\Rightarrow (-2, 8)$. In set-builder notation the interval is $\{x \mid -2 < x < 8\}$.

75. Let $Y_1 = (2 - 5X)/3$. From the table shown in Figure 75, $Y_1$ is between $-0.75$ and 0.75 for $x$-values between $-0.05$ and 0.85 and $Y_1 = 0.75$ when $x = -0.05 \Rightarrow \left[-\frac{1}{20}, \frac{17}{20}\right)$. In set-builder notation the interval is $\left\{x \mid -\frac{1}{20} \leq x < \frac{17}{20}\right\}$.

76. Let $Y_1 = (3X - 1)/5$. From the table shown in Figure 76, $Y_1 \approx 15$ when $x = 25.3$. $Y_1 < 15$ when $x < 25.3$; $(-\infty, 25.3)$. In set-builder notation the interval is $\{x \mid x < 25.3\}$.

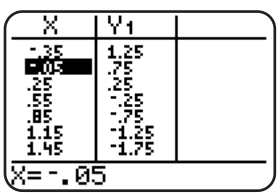


Figure 75

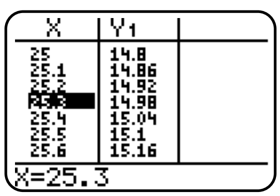


Figure 76

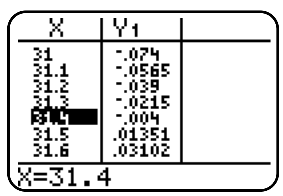


Figure 77

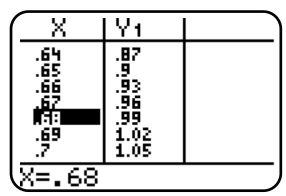


Figure 78

77. Let $Y_1 = (\sqrt{(11)} - \pi)X - 5.5$. From the table shown in Figure 77, $Y_1 \approx 0$ when $x = 31.4$. $Y_1 \leq 0$ when $x \leq 31.4$; $(-\infty, 31.4]$. In set-builder notation the interval is $\{x \mid x \leq 31.4\}$.

78. Let $Y_1 = 1.5(X - 0.7) + 1.5X$. From the table shown in Figure 78, $Y_1 \approx 1$ when $x = 0.68$. $Y_1 < 1$ when $x < 0.7$; $(-\infty, 0.7)$ In set-builder notation the interval is $\{x \mid x < 0.7\}$.

79. Symbolically: $2x - 8 > 5 \Rightarrow 2x > 13 \Rightarrow x > \frac{13}{2}$. The solution set is $\left(\frac{13}{2}, \infty\right)$. In set-builder notation the interval is $\left\{x \mid x > \frac{13}{2}\right\}$.

80. Symbolically: $5 < 4x - 2.5 \Rightarrow 7.5 < 4x \Rightarrow \frac{7.5}{4} < x \Rightarrow x > 1.875$. The solution set is $(1.875, \infty)$. In set-builder notation the interval is $\{x \mid x > 1.875\}$.

81. Graphically: Let $Y_1 = \pi X - 5.12$ and $Y_2 = \sqrt{(2)}X - 5.7(X - 1.1)$. Graph $Y_1$ and $Y_2$ as shown in Figure 81. The graphs intersect near $(1.534, -0.302)$. The graph of $Y_1$ is below $Y_2$ for $x < 1.534$, so $Y_1 \le Y_2$ when $x \le 1.534$. The solution set is $(-\infty, 1.534]$.

82. Graphically: Let $Y_1 = 5.1X - \pi$ and $Y_2 = \sqrt{(3)} - 1.7X$. Graph $Y_1$ and $Y_2$ as shown in Figure 82. The graphs intersect near $(0.717, 0.514)$. The graph of $Y_1$ is above $Y_2$ for $x > 0.717$, so $Y_1 \ge Y_2$ when $x \ge 0.717$. The solution set is $[0.717, \infty)$.

[–10, 10, 1] by [–10, 10, 1]

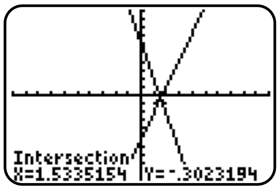



Figure 81

[–10, 10, 1] by [–10, 10, 1]

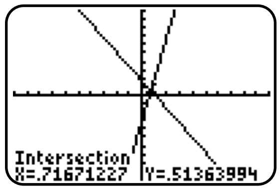



Figure 82

[0, 3, 1] by [0, 70, 10]

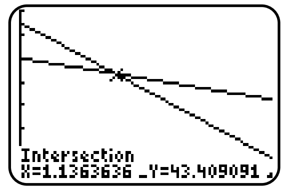



Figure 85

[0, 5, 1] by [0, 70, 10]

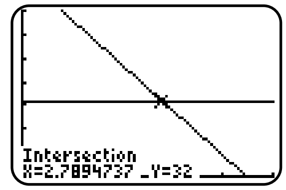



Figure 86

83. (a) Car A is traveling faster since it passes Car B. Its graph has the greater slope.

(b) The cars are the same distance from St. Louis when their graphs intersect. This point of intersection occurs at (2.5, 225). The cars are both 225 miles from St. Louis after 2.5 hours.

(c) Car B is ahead of Car A when $0 \le x < 2.5$.

84. (a) The car is moving away from Omaha since the graph has positive slope.

(b) The car is 100 miles from Omaha after 1 hour has elapsed and 200 miles away from Omaha after 3 hours.

(c) The car is 100 to 200 miles from Omaha between these times or when $1 \le x \le 3$.

(d) The distance is greater than 100 miles when $x > 1$.

85. (a) Graph $Y_1 = 65 - 19X$ and $Y_2 = 50 - 5.8X$. These graphs intersect near the point (1.14, 43.4) as shown in Figure 85. At an altitude of approximately 1.14 miles the temperature and the dew point are both equal to 43.4°F. The air temperature is greater than the dew point below 1.14 miles. The region where the clouds will not form is below 1.14 miles or when $0 \le x < 1.14$.

(b) $65 - 19x > 50 - 5.8x \Rightarrow 15 > 13.2x \Rightarrow \frac{15}{13.2} > x$ or $0 \le x < \frac{15}{13.2} \approx 1.14$

86. (a) Graph $Y_1 = 85 - 19X$ and $Y_2 = 32$. These graphs intersect near the point (2.8, 32) as shown in Figure 86. At an altitude of approximately 2.8 miles the temperature is 32°F. The temperature is below 32°F above this altitude. Since the domain is limited to an altitude of 6 miles, the region where the temperature is below freezing is above 2.8 miles and up to 6 miles. The solution is $2.8 < x \le 6$ (where 2.8 is approximate).

(b) The $x$-intercept represents the altitude where the temperature is 0°F.

(c) $T(x) = 32 \Rightarrow 85 - 19x = 32 \Rightarrow -19x = -53 \Rightarrow x = \frac{53}{19}$. Thus, $\frac{53}{19} < x \le 6$.

87. (a) The slope of the graph of $P$ is 8667. This means that the median price of a single-family home has increased by approximately \$8667 per year.

(b) Graph $Y_1 = 8667X + 90000$, $Y_2 = 142000$ and $Y_3 = 194000$. These graphs are shown in Figure 87. The points of intersection are located near (5.99, 142,000) and (11.99, 194,000). For approximately $5.99 \le x \le 11.99$ or, rounded to the nearest year, between 1996 and 2002, the median price was between \$142,000 and \$194,000. (Note that $x = 0$ corresponds to 1990.)

[0, 16, 1] by [0, 220000, 20000]

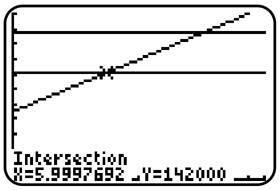



Figure 87

[1900, 2000, 10] by [0, 100, 10]

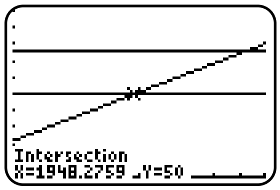



Figure 88

[2005, 2012, 1] by [30, 60, 5]

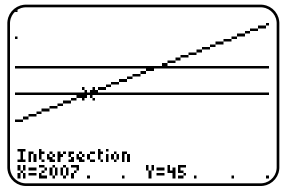



Figure 91

[2001, 2008, 1] by [300, 600, 20]

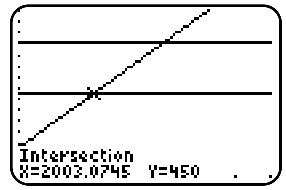



Figure 92

88. (a) The slope of the graph is 0.58. This means that the density increased on average by 0.58 people per square mile per year.

(b) Graph $Y_1 = 0.58X - 1080$, $Y_2 = 50$ and $Y_3 = 75$. The graphs are shown in Figure 88. The points of intersection are located near (1948.28, 50) and (1991.38, 75). Between approximately 1948 and 1991 the density varied between 50 and 75 in people per square mile.

89. (a) Using $(2000, 6)$ and $(2004, 30)$, find slope: $m = \dfrac{30 - 6}{2004 - 2000} = \dfrac{24}{4} = 6 \Rightarrow$

$B(x) = 6(x - 2000) + 6$ or $B(x) = 6(x - 2004) + 30$.

(b) $6(x - 2000) + 6 \ge 24 \Rightarrow 6x - 11{,}994 \ge 24 \Rightarrow 6x \ge 12{,}018 \Rightarrow x \ge 2003$, from 2003 to 2006.

90. (a) Using $(2002, 4)$ and $(2005, 10)$, find slope: $m = \dfrac{10 - 4}{2005 - 2002} = \dfrac{6}{3} = 2 \Rightarrow B(x) = 2(x - 2002) + 4$ or $B(x) = 2(x + 2005) + 10$.

(b) $2(x - 2002) + 4 \ge 6 \Rightarrow 2x - 4000 \ge 6 \Rightarrow 2x \ge 4006 \Rightarrow x \ge 2003$, consumer losses were more than \$6 billion from 2003 to 2007.

91. (a) The graph of linear function $P$ will contain the points (2005, 40) and (2011, 55).

$$m = \frac{55 - 40}{2011 - 2005} = \frac{15}{6} = 2.5 \Rightarrow P(x) = 2.5(x - 2005) + 40 \Rightarrow P(x) = 2.5x - 4972.5$$

(b) Let $Y_1 = 2.5X - 4972.5$, $Y_2 = 45$ and $Y_3 = 50$. The points of intersection are located at (2007, 45) and (2009, 50). The percentage was between 45% and 50% from 2007 to 2009. See Figure 91.

92. (a) The linear function $V$ will intersect the points (2002, 400) and (2007, 635).

$$m = \frac{635 - 400}{2007 - 2002} = \frac{235}{5} = 47 \Rightarrow V(x) = 47(x - 2002) + 400 \Rightarrow V(x) = 47x - 93{,}694$$

(b) Let $Y_1 = 47X - 93694$, $Y_2 = 450$ and $Y_3 = 540$. The points of intersection are located near (2003, 450) and (2005, 540). The annual VISA transactions were between \$450 and \$540 from 2003 to 2005. See Figure 92.

93. The graph of linear function will intersect the points (90, 6.5) and (129, 5.5).

$m = \frac{6.5 - 5.5}{90 - 129} = -\frac{1}{39} \Rightarrow f(x) = -\frac{1}{39}(x - 129) + 5.5 \Rightarrow 5.75 < -\frac{1}{39}(x - 129) + 5.5 < 6 \Rightarrow$

$0.25 < -\frac{1}{39}(x - 129) < 0.5 \Rightarrow -9.75 > x - 129 > 79.5 \Rightarrow 119.25 > x > 109.5$

94. The graph of linear function will intersect the points (77, 7) and (112, 6).

$m = \frac{7 - 6}{77 - 112} = -\frac{1}{35} \Rightarrow f(x) = -\frac{1}{35}(x - 77) + 7 \Rightarrow f(x) = -\frac{1}{35}x + 9.2 \Rightarrow$

$6\frac{1}{6} < -\frac{1}{35}x + 9.2 < 6\frac{2}{3} \Rightarrow \frac{37}{6} < -\frac{1}{35}x + \frac{46}{5} < \frac{20}{3} \Rightarrow -\frac{91}{30} < -\frac{1}{35}x < -\frac{38}{15} \Rightarrow$

$106\frac{1}{6} > x > 88\frac{2}{3}$; The sun rose between 6:10 a.m. and 6:40 a.m. from day 89 (Mar 29) to day 106 (Apr 15).

95. $r = \frac{C}{2\pi}$ and $1.99 \le r \le 2.01 \Rightarrow 1.99 \le \frac{C}{2\pi} \le 2.01 \Rightarrow 3.98\pi \le C \le 4.02\pi$

96. $s = \frac{P}{4}$ and $9.9 \le s \le 10.1 \Rightarrow 9.9 \le \frac{P}{4} \le 10.1 \Rightarrow 39.6 \le P \le 40.4$

97. (a) $m = \frac{4.5 - (-1.5)}{2 - 0} = \frac{6}{2} = 3$ and $y$-intercept $= -1.5$; $f(x) = 3x - 1.5$ models the data.

(b) $f(x) > 2.25 \Rightarrow 3x - 1.5 > 2.25 \Rightarrow 3x > 3.75 \Rightarrow x > 1.25$

98. (a) $m = \frac{3.5 - 0.4}{2 - 1} = 3.1$ and $y$-intercept $= 0.4 - 3.1 = -2.7$; $f(x) = 3.1x - 2.7$ models the data.

(b) $2 \le f(x) \le 8 \Rightarrow 2 \le 3.1x - 2.7 \le 8 \Rightarrow 4.7 \le 3.1x \le 10.7 \Rightarrow 1.52 \le x \le 3.45$ (approximate)

99. (a) Using the linear regression function on the calculator the function *f* is found to be

$f(x) = 20.1x - 40{,}0096.7$.

(b) Let $Y_1 = 20.1X - 40096.7$, $Y_2 = 43$ and $Y_3 = 83$. The points of intersection are at (1997, 43) and near (1999, 83). Therefore, the number of cell phone subscribers was between 43 and 83 million between the years 1997 and 1999.

(c) The answer was a result of extrapolation.

100. (a) Using the linear regression function on the calculator the function *f* is found to be

$f(x) \approx 0.21233x - 357.206$.

(b) Let $Y_1 = 0.21233X - 357.206$, $Y_2 = 58$ and $Y_3 = 60$. The points of intersection are near (1955, 58) and (1965, 60). The percentage of homes owned by the occupant was between 58% and 60% between the years 1955 and 1965.

(c) The answer was a result of interpolation.

## Extended and Discovery Exercises for Section 2.4

1. $a < b \Rightarrow 2a < a + b < 2b \Rightarrow a < \frac{a + b}{2} < b$

2. $0 < a < b \Rightarrow a^2 < ab < b^2 \Rightarrow a < \sqrt{ab} < b$

## Checking Basic Concepts for Sections 2.3 and 2.4

1. (a) Using the $x$-intercept method, graph $Y_1 = 4(x - 2) - 2(5 - x) + 3$. See Figure 1a.

   Since $Y_1 = 0$ when $x = 2.5$, the solution to the linear equation is 2.5.

   (b) Table $Y_1 = 4(x - 2) - 2(5 - x) + 3$ as shown in Figure 1b.

   Since $Y_1 = 0$ when $x = 2.5$, the solution to the linear equation is 2.5.

   (c) $4(x - 2) = 2(5 - x) - 3 \Rightarrow 4x - 8 = 10 - 2x - 3 \Rightarrow 6x = 15 \Rightarrow x = 2.5$

[−10, 10, 1] by [−10, 10, 1]

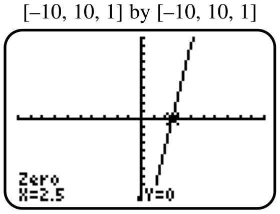



Figure 1a

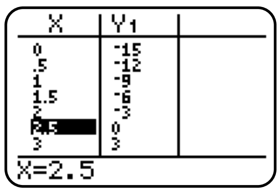



Figure 1b

2. $2(x - 4) > 1 - x \Rightarrow 2x - 8 > 1 - x \Rightarrow 3x > 9 \Rightarrow x > 3$; $\{x|x > 3\}$

3. $-2 \le 1 - 2x \le 3 \Rightarrow -3 \le -2x \le 2 \Rightarrow \frac{3}{2} \ge x \ge -1$, or $-1 \le x \le \frac{3}{2}$; $\left[-1, \frac{3}{2}\right]$ In set-builder notation the interval is $\left\{x|-1 \le x \le \frac{3}{2}\right\}$.

4. (a) $-3(2 - x) - \frac{1}{2}x - \frac{3}{2} = 0$ when $x = 3$; symbolically, $-3(2 - x) - \frac{1}{2}x - \frac{3}{2} = 0 \Rightarrow$

   $-6 + 3x - \frac{1}{2}x - \frac{3}{2} = 0 \Rightarrow \frac{5}{2}x - \frac{15}{2} = 0 \Rightarrow \frac{5}{2}x = \frac{15}{2} \Rightarrow x = 3$

   (b) $-3(2 - x) - \frac{1}{2}x - \frac{3}{2} > 0$ when $x > 3$; symbolically, $-3(2 - x) - \frac{1}{2}x - \frac{3}{2} > 0 \Rightarrow$

   $-6 + 3x - \frac{1}{2}x - \frac{3}{2} > 0 \Rightarrow \frac{5}{2}x - \frac{15}{2} > 0 \Rightarrow \frac{5}{2}x > \frac{15}{2} \Rightarrow x > 3 \Rightarrow (3, \infty)$. In set-builder notation the interval is $\{x|x > 3\}$.

   (c) $-3(2 - x) - \frac{1}{2}x - \frac{3}{2} \le 0$ when $x \le 3$; symbolically, $-3(2 - x) - \frac{1}{2}x - \frac{3}{2} \le 0 \Rightarrow$

   $-6 + 3x - \frac{1}{2}x - \frac{3}{2} \le 0 \Rightarrow \frac{5}{2}x - \frac{15}{2} \le 0 \Rightarrow \frac{5}{2}x \le \frac{15}{2} \Rightarrow x \le 3 \Rightarrow (-\infty, 3]$. In set-builder notation the interval is $\{x|x \le 3\}$.

## 2.5: Absolute Value Equations and Inequalities

1. $|x| = 3 \Rightarrow x = 3$ or $x = -3$
2. $|x| \le 3 \Rightarrow -3 \le x \le 3$; $[-3, 3]$
3. $|x| > 3 \Rightarrow x > 3$ or $x < -3$; $(-\infty, -3) \cup (3, \infty)$
4. $|ax + b| \le -2$ compared to form $|ax + b| \le k \Rightarrow k = -2$; $k < 0$. Thus, the absolute value equation has no solutions.

5. The graph of $y = |ax + b|$ is V-shaped with the vertex on the $x$-axis.

6. $|ax + b| = 0 \Rightarrow ax + b = 0 \Rightarrow ax = -b \Rightarrow x = -\dfrac{b}{a}$.

7. $\sqrt{36a^2} = |6a|$ since 36 and $a^2$ are always positive values.

8. $\sqrt{(ax + b)^2} = |ax + b|$ since $(ax + b)^2$ is always a positive value.

9. (a) $x + 1 = 0 \Rightarrow x = -1 \Rightarrow$ the vertex is $(-1, 0)$. Find any other point, $x = 0 \Rightarrow (0, 1)$; graph the absolute value graph with the vertex $(-1, 0)$, point $(0, 1)$ and its reflection through $x = -1$. See Figure 9.

   (b) $y = |x + 1|$ is increasing on $x \geq -1$ or $[-1, \infty)$ and decreasing on $x \leq -1$ or $(-\infty, -1]$.

10. (a) $1 - x = 0 \Rightarrow -x = -1 \Rightarrow$ the vertex is $(1, 0)$. Find another point such as $(0, 1)$, graph the absolute value function. See Figure 10.

   (b) $y = |1 - x|$ is increasing on $x \geq 1$ or $[1, \infty)$ and decreasing on $x \leq 1$ or $(-\infty, 1]$.

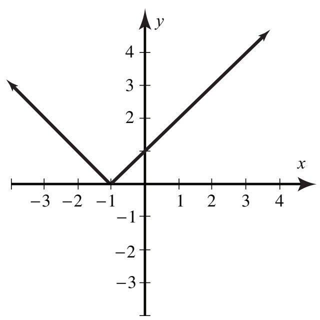


Figure 9

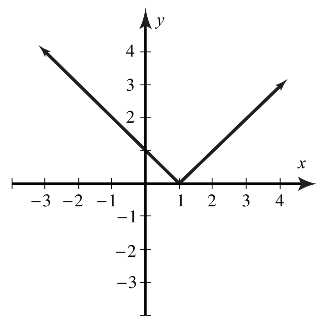


Figure 10

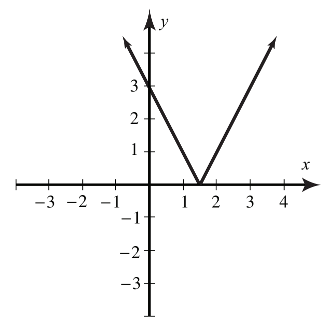


Figure 11

11. (a) $2x - 3 = 0 \Rightarrow 2x = 3 \Rightarrow x = \dfrac{3}{2} \Rightarrow$ the vertex is $\left(\dfrac{3}{2}, 0\right)$. Find another point such as $(0, 3)$; graph the absolute value function. See Figure 11.

   (b) $y = |2x - 3|$ is increasing on $x \geq \dfrac{3}{2}$ or $\left[\dfrac{3}{2}, \infty\right)$ and decreasing on $x \leq \dfrac{3}{2}$ or $\left(-\infty, \dfrac{3}{2}\right]$.

12. (a) $\dfrac{1}{2}x + 1 = 0 \Rightarrow \dfrac{1}{2}x = -1 \Rightarrow x = -2 \Rightarrow$ the vertex is $(-2, 0)$. Find another point such as $(0, 1)$; graph the absolute value function. See Figure 12.

   (b) $y = \left|\dfrac{1}{2}x + 1\right|$ is increasing on $x \geq -2$ or $[-2, \infty)$ and decreasing on $x \leq -2$ or $(-\infty, -2]$.

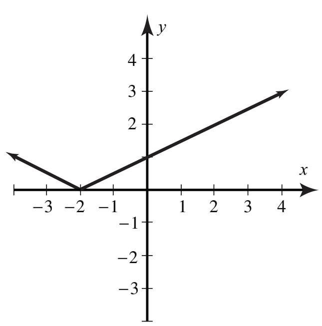


Figure 12

13. (a) The graph of $y_1 = 2x$ is shown in Figure 13a.

(b) The graph of $y = |2x|$ is similar to the graph of $y = 2x$ except that it is reflected across the $x$-axis whenever $2x < 0$. The graph of $y_1 = |2x|$ is shown in Figure 13b.

(c) The $x$-intercept occurs when $2x = 0$ or when $x = 0$. The $x$-intercept is 0.

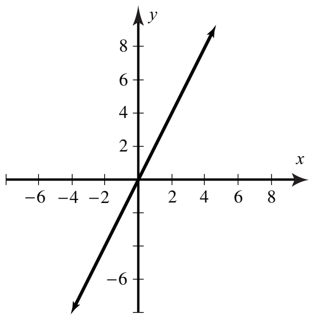


Figure 13a

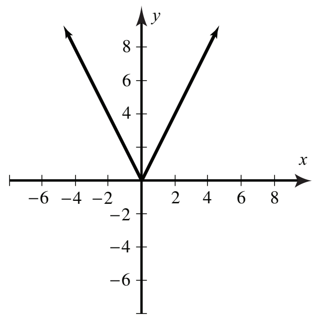


Figure 13b

14. (a) The graph of $y_1 = \frac{1}{2}x$ is shown in Figure 14a.

(b) The graph of $y = \left|\frac{1}{2}x\right|$ is similar to the graph of $y = \frac{1}{2}x$ except that it is reflected across the $x$-axis whenever $\frac{1}{2}x < 0$. The graph of $y_1 = \left|\frac{1}{2}x\right|$ is shown in Figure 14b.

(c) The $x$-intercept occurs when $\frac{1}{2}x = 0$ or when $x = 0$. The $x$-intercept is located at 0.

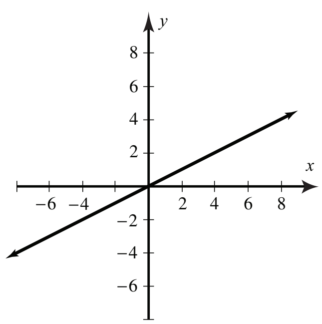


Figure 14a

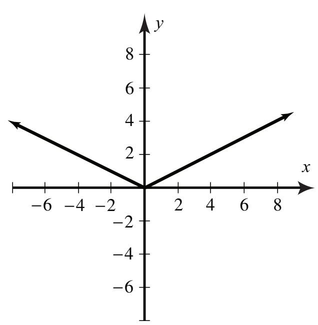


Figure 14b

15. (a) The graph of $y_1 = 3x - 3$ is shown in Figure 15a.

(b) The graph of $y = |3x - 3|$ is similar to the graph of $y = 3x - 3$ except that it is reflected across the $x$-axis whenever $3x - 3 < 0$ or $x < 1$. The graph of $y_1 = |3x - 3|$ is shown in Figure 15b.

(c) The $x$-intercept occurs when $3x - 3 = 0$ or when $x = 1$. The $x$-intercept is located at 1.

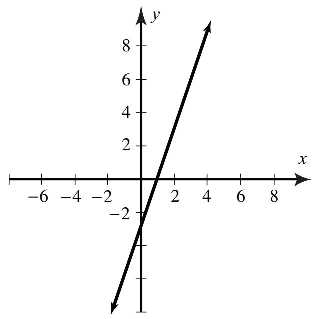


Figure 15a

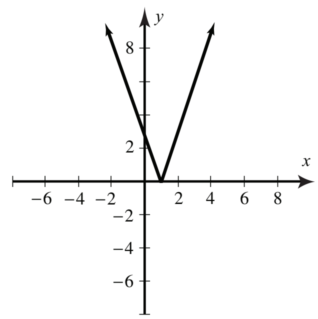


Figure 15b

16. (a) The graph of $y_1 = 2x - 4$ is shown in Figure 16a.

    (b) The graph of $y = |2x - 4|$ is similar to the graph of $y = 2x - 4$ except that it is reflected across the $x$-axis whenever $2x - 4 < 0$ or $x < 2$. The graph of $y_1 = |2x - 4|$ is shown in Figure 16b.

    (c) The $x$-intercept occurs when $2x - 4 = 0$ or when $x = 2$. The $x$-intercept is located at 2.

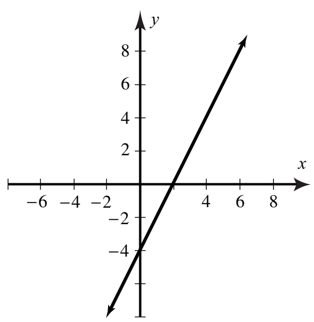


Figure 16a

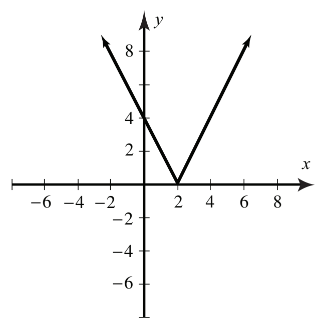


Figure 16b

17. (a) The graph of $y_1 = 6 - 2x$ is shown in Figure 17a.

    (b) The graph of $y = |6 - 2x|$ is similar to the graph of $y = 6 - 2x$ except that it is reflected across the $x$-axis whenever $6 - 2x < 0$ or $x > 3$. The graph of $y_1 = |6 - 2x|$ is shown in Figure 17b.

    (c) The $x$-intercept occurs when $6 - 2x = 0$ or when $x = 3$. The $x$-intercept is located at 3.

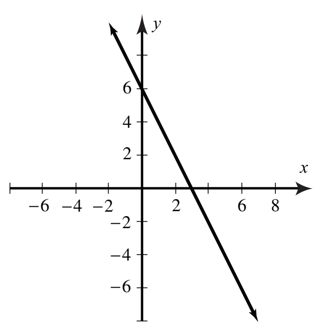


Figure 17a

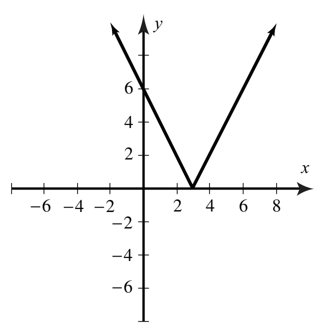


Figure 17b

18. (a) The graph of $y_1 = 2 - 4x$ is shown in Figure 18a.

(b) The graph of $y = |2 - 4x|$ is similar to the graph of $y = 2 - 4x$ except that it is reflected across the $x$-axis whenever $2 - 4x < 0$ or $x > \frac{1}{2}$. The graph of $y_1 = |2 - 4x|$ is shown in Figure 18b.

(c) The $x$-intercept occurs when $2 - 4x = 0$ or when $x = \frac{1}{2}$. The $x$-intercept is located at $\frac{1}{2}$.

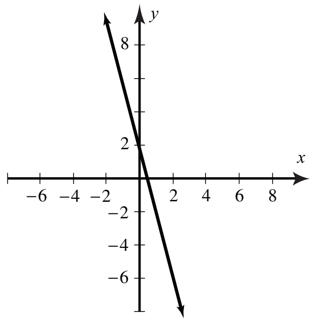


Figure 18a

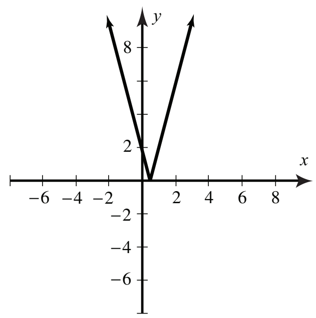


Figure 18b

19. $|-2x| = 4 \Rightarrow -2x = 4$ or $-2x = -4 \Rightarrow 2x = -4$ or $2x = 4 \Rightarrow x = -2$ or $2$

20. $|3x| = -6$ has no solutions since the absolute value of any quantity is always greater than or equal to 0.

21. $|5x - 7| = 2 \Rightarrow 5x - 7 = -2$ or $5x - 7 = 2$. If $5x - 7 = -2$, then $5x = 5 \Rightarrow x = 1$;
If $5x - 7 = 2$, then $5x = 9 \Rightarrow x = \frac{9}{5}$; $1, \frac{9}{5}$.

22. $|-3x - 2| = 5 \Rightarrow -3x - 2 = -5$ or $-3x - 2 = 5$. If $-3x - 2 = -5$, then $-3x = -3 \Rightarrow x = 1$;
If $-3x - 2 = 5$ then $-3x = 7 \Rightarrow x = -\frac{7}{3}$; $-\frac{7}{3}, 1$.

23. $|3 - 4x| = 5 \Rightarrow 3 - 4x = -5$ or $3 - 4x = 5$. If $3 - 4x = -5$, then $-4x = -8 \Rightarrow x = 2$;
If $3 - 4x = 5$ then $-4x = 2 \Rightarrow x = -\frac{1}{2}$; $-\frac{1}{2}, 2$.

24. $|2 - 3x| = 1 \Rightarrow 2 - 3x = -1$ or $2 - 3x = 1$. If $2 - 3x = -1$, then $-3x = -3 \Rightarrow x = 1$;
If $2 - 3x = 1$, then $-3x = -1 \Rightarrow x = \frac{1}{3}$; $\frac{1}{3}, 1$.

25. $|-6x - 2| = 0 \Rightarrow -6x - 2 = 0 \Rightarrow -6x = 2 \Rightarrow x = -\frac{1}{3}$.

26. $|6x - 9| = 0 \Rightarrow 6x - 9 = 0 \Rightarrow 6x = 9 \Rightarrow x = \frac{3}{2}$.

27. $|7 - 16x| = 0 \Rightarrow 7 - 16x = 0 \Rightarrow 7 = 16x \Rightarrow x = \frac{7}{16}$.

28. $|-x - 4| = 0 \Rightarrow -x - 4 = 0 \Rightarrow -4 = x \Rightarrow x = -4$.

29. $|17x - 6| = -3$ has no solutions since the absolute value of any quantity is always greater than or equal to 0.

30. $|-8x - 11| = -7$ has no solutions since the absolute value of any quantity is always greater than or equal to 0.

31. $|1.2x - 1.7| - 1 = 3 \Rightarrow |1.2x - 1.7| = 4$, then $1.2x - 1.7 = -4$ or $1.2x - 1.7 = 4$.
If $1.2x - 1.7 = -4$ then, $1.2x = -2.3 \Rightarrow x = -\frac{2.3}{1.2} \Rightarrow x = -\frac{23}{12}$; if $1.2x - 1.7 = 4$ then
$1.2x = 5.7 \Rightarrow x = \frac{5.7}{1.2} \Rightarrow x = \frac{19}{4}$; $\Rightarrow -\frac{23}{12}, \frac{19}{4}$.

32. $|3 - 3x| - 2 = 2 \Rightarrow |3 - 3x| = 4$, then $3 - 3x = -4$ or $3 - 3x = 4$. If $3 - 3x = -4$ then $-3x = -7 \Rightarrow x = \frac{7}{3}$; if $3 - 3x = 4$ then $-3x = 1 \Rightarrow x = -\frac{1}{3} \Rightarrow -\frac{1}{3}, \frac{7}{3}$.

33. $|4x - 5| + 3 = 2 \Rightarrow |4x - 5| = -1$ has no solution since the absolute value of any quantity is always greater than or equal to 0.

34. $|4.5 - 2x| + 1.1 = 9.7 \Rightarrow |4.5 - 2x| = 8.6 \Rightarrow 4.5 - 2x = -8.6$ or $4.5 - 2x = 8.6 \Rightarrow$ $x = -2.05, 6.55$

35. $|2x - 9| = |8 - 3x| \Rightarrow 2x - 9 = 8 - 3x$ or $2x - 9 = -(8 - 3x) \Rightarrow$ $2x + 3x = 8 + 9$ or $2x - 3x = -8 + 9 \Rightarrow 5x = 17$ or $-x = 1 \Rightarrow x = \frac{17}{5}, -1$

36. $|x - 3| = |8 - x| \Rightarrow x - 3 = 8 - x$ or $x - 3 = -(8 - x) \Rightarrow$ $x + x = 8 + 3$ or $x - x = -8 + 3 \Rightarrow 2x = 11$ or $0 = -5 \Rightarrow x = \frac{11}{2}$

37. $\left|\frac{3}{4}x - \frac{1}{4}\right| = \left|\frac{3}{4} - \frac{1}{4}x\right| \Rightarrow \frac{3}{4}x - \frac{1}{4} = \frac{3}{4} - \frac{1}{4}x$ or $\frac{3}{4}x - \frac{1}{4} = -\left(\frac{3}{4} - \frac{1}{4}x\right) \Rightarrow$ $\frac{3}{4}x + \frac{1}{4}x = \frac{3}{4} + \frac{1}{4}$ or $\frac{3}{4}x - \frac{1}{4}x = -\frac{3}{4} + \frac{1}{4} \Rightarrow x = 1$ or $\frac{1}{2}x = -\frac{1}{2} \Rightarrow x = -1, 1$

38. $\left|\frac{1}{2}x + \frac{3}{2}\right| = \left|\frac{3}{2}x - \frac{7}{2}\right| \Rightarrow \frac{1}{2}x + \frac{3}{2} = \frac{3}{2}x - \frac{7}{2}$ or $\frac{1}{2}x + \frac{3}{2} = -\left(\frac{3}{2}x - \frac{7}{2}\right) \Rightarrow$ $\frac{1}{2}x + \frac{3}{2} = \frac{3}{2}x - \frac{7}{2} \Rightarrow -x = -5 \Rightarrow x = 5$ or $\frac{1}{2}x + \frac{3}{2} = -\left(\frac{3}{2}x - \frac{7}{2}\right) \Rightarrow \frac{1}{2}x + \frac{3}{2} = -\frac{3}{2}x + \frac{7}{2} \Rightarrow$ $2x = 2 \Rightarrow x = 1 \Rightarrow x = 1, 5$

39. $\left|15x - 5\right| = \left|35 - 5x\right| \Rightarrow 15x - 5 = 35 - 5x$ or $15x - 5 = -(35 - 5x) \Rightarrow$ $15x - 5 = 35 - 5x \Rightarrow 20x = 40 \Rightarrow x = 2$ or $15x - 5 = -(35 - 5x) \Rightarrow 15x - 5 = -35 + 5x \Rightarrow$ $10x = -30 \Rightarrow x = -3 \Rightarrow x = -3$ or $2$

40. $|20x - 40| = |80 - 20x| \Rightarrow 20x - 40 = 80 - 20x$ or $20x - 40 = -(80 - 20x) \Rightarrow$ $20x + 20x = 80 + 40 \Rightarrow 40x = 120 \Rightarrow x = 3$; $20x - 20x = -80 + 40 \Rightarrow 0 = -40 \Rightarrow x = 3$

41. (a) $f(x) = g(x)$ when $x = -1$ or 7.

    (b) $f(x) < g(x)$ between these $x$-values or when $-1 < x < 7$; $(-1, 7)$

    (c) $f(x) > g(x)$ outside of these $x$-values or when $x < -1$ or $x > 7$; $(-\infty, -1) \cup (7, \infty)$

42. (a) $f(x) = g(x)$ when $x = -4$ or 8.

    (b) $f(x) \le g(x)$ between and including these $x$-values or when $-4 \le x \le 8$; $[-4, 8]$

    (c) $f(x) \ge g(x)$ outside of and including these $x$-values or when $x \le -4$ or $x \ge 8$; $(-\infty, -4] \cup [8, \infty)$

43. (a) $|2x - 3| = 1 \Rightarrow 2x - 3 = 1$ or $2x - 3 = -1$. If $2x - 3 = 1$, then $2x = 4 \Rightarrow x = 2$; If $2x - 3 = -1$ then $2x = 2 \Rightarrow x = 1$; $x = 1$ or $x = 2$

    (b) $|2x - 3| < 1 \Rightarrow -1 < 2x - 3 < 1 \Rightarrow 2 < 2x < 4 \Rightarrow 1 < x < 2$; $(1, 2)$

    (c) $|2x - 3| > 1 \Rightarrow 2x - 3 > 1$ or $2x - 3 < -1$. If $2x - 3 > 1$, then $2x > 4 \Rightarrow x > 2$. If $2x - 3 < -1$, then $2x < 2 \Rightarrow x < 1$. $x < 1$ or $x > 2$ or $(-\infty, 1) \cup (2, \infty)$

44. (a) $|5 - x| = 2 \Rightarrow 5 - x = 2$ or $5 - x = -2$. If $5 - x = 2$ then $-x = -3 \Rightarrow x = 3$. Or if

$5 - x = -2$ then $-x = -7 \Rightarrow x = 7$. $x = 3$ or $x = 7$.

(b) $|5 - x| \le 2 \Rightarrow -2 \le 5 - x \le 2 \Rightarrow -7 \le -x \le -3 \Rightarrow 7 \ge x \ge 3 \Rightarrow 3 \le x \le 7$; $[3, 7]$

(c) $|5 - x| \ge 2 \Rightarrow 5 - x \ge 2$ or $5 - x \le -2$. If $5 - x \ge 2$, then $-x \ge -3 \Rightarrow x \le 3$.

If $5 - x \le -2$, then $-x \le -7 \Rightarrow x \ge 7$; $x \le 3$ or $x \ge 7$; $(-\infty, 3] \cup [7, \infty)$

45. (a) Graph $Y_1 = \text{abs}(2X - 5)$ and $Y_2 = 10$. See Figures 45a and 45b. The solutions are $-2.5$ and 7.5.

(b) Table $Y_1 = \text{abs}(2X - 5)$ starting at –5, incrementing by 2.5. See Figure 45c. The solutions are $-2.5$ and 7.5.

(c) $|2x - 5| = 10 \Rightarrow 2x - 5 = -10$ or $2x - 5 = 10 \Rightarrow x = -\dfrac{5}{2}$ or $\dfrac{15}{2}$

From each method, the solution to $|2x - 5| < 10$ lies between –2.5 and 7.5, exclusively: $-2.5 < x < 7.5$

or $\left(-\dfrac{5}{2}, \dfrac{15}{2}\right)$.

[–10, 10, 1] by [–5, 15, 1]

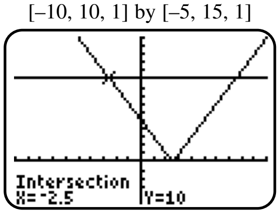


Figure 45a

[–10, 10, 1] by [–5, 15, 1]

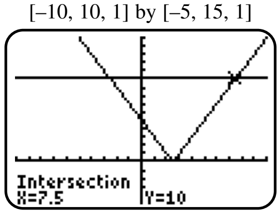


Figure 45b

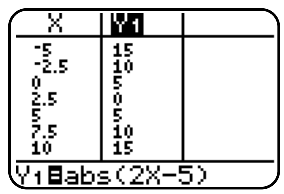


Figure 45c

46. (a) Graph $Y_1 = \text{abs}(3X - 4)$ and $Y_2 = 8$. See Figures 46a and 46b. The solutions are $-\dfrac{4}{3}$ and 4.

(b) Table $Y_1 = \text{abs}(3X - 4)$ starting at $-\dfrac{8}{3}$, incrementing by $\dfrac{4}{3}$. See Figure 46c. The solutions are $-\dfrac{4}{3}$ and 4.

(c) $|3x - 4| = 8 \Rightarrow 3x - 4 = -8$ or $3x - 4 = 8 \Rightarrow x = -\dfrac{4}{3}$ or 4

From each method, the solution to $|3x - 4| \le 8$ lies between $-\dfrac{4}{3}$ and 4, inclusively: $-\dfrac{4}{3} \le x \le 4$ or

$\left[-\dfrac{4}{3}, 4\right]$.

[–10, 10, 1] by [–5, 15, 1]

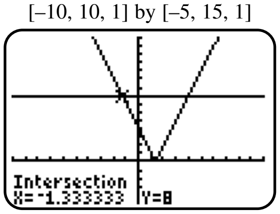


Figure 46a

[–10, 10, 1] by [–5, 15, 1]

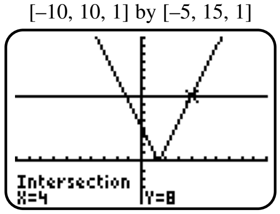


Figure 46b

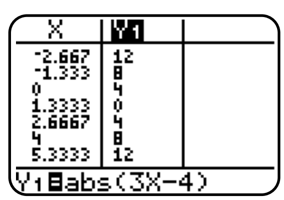


Figure 46c

47. (a) Graph $Y_1 = \text{abs}(5 - 3X)$ and $Y_2 = 2$. See Figures 47a and 47b. The solutions are 1 and $\frac{7}{3}$.

(b) Table $Y_1 = \text{abs}(5 - 3X)$ starting at $-\frac{1}{3}$, incrementing by $\frac{2}{3}$. See Figure 47c. The solutions are 1 and $\frac{7}{3}$.

(c) $|5 - 3x| = 2 \Rightarrow 5 - 3x = -2$ or $5 - 3x = 2 \Rightarrow x = \frac{7}{3}$ or 1

From each method, the solution to $|5 - 3x| > 2$ lies outside of 1 and $\frac{7}{3}$, exclusively: $x < 1$ or $x > \frac{7}{3}$ or $(-\infty, 1) \cup \left(\frac{7}{3}, \infty\right)$.

[–1, 4, 1] by [–1, 3, 1]

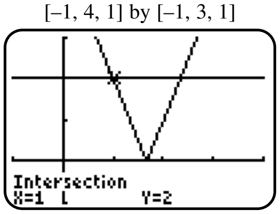


Figure 47a

[–1, 4, 1] by [–1, 3, 1]

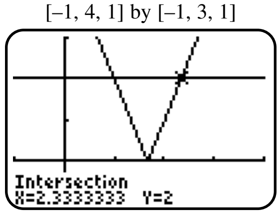


Figure 47b

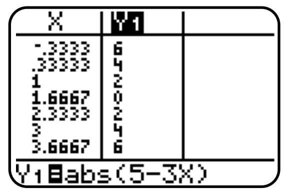


Figure 47c

48. (a) Graph $Y_1 = \text{abs}(4X - 7)$ and $Y_2 = 5$. See Figures 48a and 48b. The solutions are 0.5 and 3.

(b) Table $Y_1 = \text{abs}(4X - 7)$ starting at –2, incrementing by 1.25. See Figure 48c. The solutions are 0.5 and 3.

(c) $|4x - 7| = 5 \Rightarrow 4x - 7 = -5$ or $4x - 7 = 5 \Rightarrow x = \frac{1}{2}$ or 3

From each method, the solution to $|4x - 7| \geq 5$ lies outside of $\frac{1}{2}$ and 3, inclusively: $x \leq \frac{1}{2}$ or $x \geq 3$ or $\left(-\infty, \frac{1}{2}\right] \cup [3, \infty]$.

[–1, 4, 1] by [–3, 7, 1]

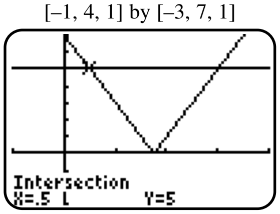


Figure 48a

[–1, 4, 1] by [–3, 7, 1]

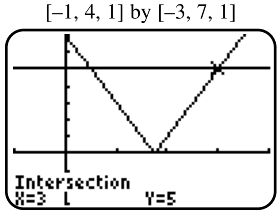


Figure 48b

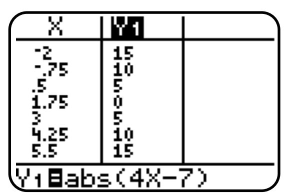


Figure 48c

49. $|2.1x - 0.7| = 2.4 \Rightarrow 2.1x - 0.7 = -2.4$ or $2.1x - 0.7 = 2.4 \Rightarrow x = -\frac{17}{21}$ or $\frac{31}{21}$

The solution to $|2.1x - 0.7| \geq 2.4$ lies outside of $-\frac{17}{21}$ and $\frac{31}{21}$, inclusively: $x \leq -\frac{17}{21}$ or $x \geq \frac{31}{21}$ or $\left(-\infty, -\frac{17}{21}\right] \cup \left[\frac{31}{21}, \infty\right)$.

50. $\left|\frac{1}{2}x - \frac{3}{4}\right| = \frac{7}{4} \Rightarrow \frac{1}{2}x - \frac{3}{4} = -\frac{7}{4}$ or $\frac{1}{2}x - \frac{3}{4} = \frac{7}{4} \Rightarrow x = -2$ or 5

The solution to $\left|\frac{1}{2}x - \frac{3}{4}\right| \leq \frac{7}{4}$ lies between –2 and 5, inclusively: $-2 \leq x \leq 5$ or $[-2, 5]$.

51. $|3x| + 5 = 6 \Rightarrow |3x| = 1 \Rightarrow 3x = -1$ or $3x = 1 \Rightarrow x = -\frac{1}{3}$ or $\frac{1}{3}$.

The solution to $|3x| + 5 > 6$ lies outside of $-\frac{1}{3}$ and $\frac{1}{3}$, exclusively: $x < -\frac{1}{3}$, $x > \frac{1}{3}$,

$\left(-\infty, -\frac{1}{3}\right) \cup \left(\frac{1}{3}, \infty\right)$.

52. $|x| - 10 = 25 \Rightarrow |x| = 35 \Rightarrow x = -35$ or $35$.

The solution to $|x| - 10 < 25$ lies between –35 and 35, exclusively: $-35 < x < 35$ or $(-35, 35)$.

53. $\left|\frac{2}{3}x - \frac{1}{2}\right| = -\frac{1}{4}$ has no solutions since the absolute value of any quantity is always greater than or equal to 0.

There are no solutions to $\left|\frac{2}{3}x - \frac{1}{2}\right| \le -\frac{1}{4}$.

54. $|5x - 0.3| = -4$ has no solutions since the absolute value of any quantity is always greater than or equal to 0.

The solution set for $|5x - 0.3| > -4$ includes all real numbers since $|5x - 0.3|$ is always greater than any negative value.

55. The solutions to $|3x - 1| < 8$ satisfy $s_1 < x < s_2$ where $s_1$ and $s_2$, are the solutions to $|3x - 1| = 8$.

$|3x - 1| = 8$ is equivalent to $3x - 1 = -8 \Rightarrow x = -\frac{7}{3}$ or $3x - 1 = 8 \Rightarrow x = 3$.

The interval is $\left(-\frac{7}{3}, 3\right)$.

56. The solutions to $|15 - x| < 7$ satisfy $s_1 < x < s_2$, where $s_1$ and $s_2$ are the solutions to $|15 - x| = 7$.

$|15 - x| = 7$ is equivalent to $15 - x = -7 \Rightarrow x = 22$ or $15 - x = 7 \Rightarrow x = 8$.

The interval is $(8, 22)$.

57. The solutions to $|7 - 4x| \le 11$ satisfy $s_1 \le x \le s_2$, where $s_1$ and $s_2$ are the solutions to $|7 - 4x| = 11$.

$|7 - 4x| = 11$ is equivalent to $7 - 4x = -11 \Rightarrow x = \frac{9}{2}$ or $7 - 4x = 11 \Rightarrow x = -1$.

The interval is $\left[-1, \frac{9}{2}\right]$.

58. The solutions to $|-3x + 1| \le 5$ satisfy $s_1 \le x \le s_2$, where $s_1$ and $s_2$ are the solutions to $|-3x + 1| = 5$.

$|-3x + 1| = 5$ is equivalent to $-3x + 1 = -5 \Rightarrow x = 2$ or $-3x + 1 = 5 \Rightarrow x = -\frac{4}{3}$.

The interval is $\left[-\frac{4}{3}, 2\right]$.

59. The solutions to $|0.5x - 0.75| < 2$ satisfy $s_1 < x < s_2$, where $s_1$ and $s_2$ are the solutions to $|0.5x - 0.75| = 2$.

$|0.5x - 0.75| = 2$ is equivalent to $0.5x - 0.75 = -2 \Rightarrow x = -\frac{5}{2}$ or $0.5x - 0.75 = 2 \Rightarrow x = \frac{11}{2}$.

The interval is $\left(-\frac{5}{2}, \frac{11}{2}\right)$.

60. The solutions to $|2.1x - 5| \le 8$ satisfy $s_1 \le x \le s_2$, where $s_1$ and $s_2$ are the solutions to $|2.1x - 5| = 8$.

 $|2.1x - 5| = 8$ is equivalent to $2.1x - 5 = -8 \Rightarrow x = -\dfrac{10}{7}$ or $2.1x - 5 = 8 \Rightarrow x = \dfrac{130}{21}$.

 The interval is $\left[-\dfrac{10}{7}, \dfrac{130}{21}\right]$.

61. The solutions to $|2x - 3| > 1$ satisfy $x < s_1$ or $x > s_2$, where $s_1$ and $s_2$ are the solutions to $|2x - 3| = 1$.

 $|2x - 3| = 1$ is equivalent to $2x - 3 = -1 \Rightarrow x = 1$ or $2x - 3 = 1 \Rightarrow x = 2$.

 The solution set is $(-\infty, 1) \cup (2, \infty)$.

62. The solutions to $|5x - 7| > 2$ satisfy $x < s_1$ or $x > s_2$, where $s_1$ and $s_2$ are the solutions to $|5x - 7| = 2$.

 $|5x - 7| = 2$ is equivalent to $5x - 7 = -2 \Rightarrow x = 1$ or $5x - 7 = 2 \Rightarrow x = \dfrac{9}{5}$.

 The solution set is $(-\infty, 1) \cup \left(\dfrac{9}{5}, \infty\right)$.

63. The solutions to $|-3x + 8| \ge 3$ satisfy $x \le s_1$ or $x \ge s_2$, where $s_1$ and $s_2$ are the solutions to $|-3x + 8| = 3$.

 $|-3x + 8| = 3$ is equivalent to $-3x + 8 = -3 \Rightarrow x = \dfrac{11}{3}$ or $-3x + 8 = 3 \Rightarrow x = \dfrac{5}{3}$.

 The solution set is $\left(-\infty, \dfrac{5}{3}\right] \cup \left[\dfrac{11}{3}, \infty\right)$.

64. The solutions to $|-7x - 3| \ge 5$ satisfy $x \le s_1$ or $x \ge s_2$, where $s_1$ and $s_2$ are the solutions to $|-7x - 3| = 5$.

 $|-7x - 3| = 5$ is equivalent to $-7x - 3 = -5 \Rightarrow x = \dfrac{2}{7}$ or $-7x - 3 = 5 \Rightarrow x = -\dfrac{8}{7}$.

 The solution set is $\left(-\infty, -\dfrac{8}{7}\right] \cup \left[\dfrac{2}{7}, \infty\right)$.

65. The solutions to $|0.25x - 1| > 3$ satisfy $x < s_1$ or $x > s_2$, where $s_1$ and $s_2$ are the solutions to $|0.25x - 1| = 3$.

 $|0.25x - 1| = 3$ is equivalent to $0.25x - 1 = -3 \Rightarrow x = -8$ or $0.25x - 1 = 3 \Rightarrow x = 16$.

 The solution set is $(-\infty, -8) \cup (16, \infty)$.

66. The solutions to $|-0.5x + 5| \ge 4$ satisfy $x \le s_1$ or $x \ge s_2$, where $s_1$ and $s_2$ are the solutions to $|-0.5x + 5| = 4$.

 $|-0.5x + 5| = 4$ is equivalent to $-0.5x + 5 = -4 \Rightarrow x = 18$ or $-0.5x + 5 = 4 \Rightarrow x = 2$.

 The solution set is $(-\infty, 2] \cup [18, \infty)$.

67. $|-6| = 6$

68. $|17| = 17$

69. Since the inputs of absolute values can be positive or negative, the domain of $|f(x)|$ is also $[-2, 4]$.

70. Since the inputs of absolute values can be positive or negative, the domain of $|f(x)|$ is also $[-\infty, 0]$.

71. Since all solutions or the range of absolute values must be non-negative, all negative solutions will change to positive solutions; therefore, if the range of $f(x)$ is $(-\infty, 0]$, the range of $|f(x)|$ is $[0, \infty)$.

72. All negative solutions will change to positive solutions; therefore, if the range of $f(x)$ is $(-4, 5)$, the range of $|f(x)|$ is $[0, 5)$.

73. $|S - 57.5| = 17.5 \Rightarrow S - 57.5 = 17.5$ or $S - 57.5 = -17.5$. If $S - 57.5 = 17.5$, then $S = 75$. If $S - 57.5 = -17.5$, then $S = 40$. Therefore, the maximum speed limit is 75 mph and the minimum speed limit is 40 mph.

74. (a) Since the performer wants to land in a net with side length 70, the performer has 35 feet on each side of 180 feet to land safely. Therefore, the performer can travel a maximum of $180 + 35 = 215$ feet or a minimum of $180 - 35 = 145$ feet.

(b) The above scenario can be modeled using $|D - 180| \le 35$.

75. (a) $0 \le 80 - 19x \le 32 \Rightarrow -80 \le -19x \le -48 \Rightarrow \frac{80}{19} \ge x \ge \frac{48}{19} \Rightarrow \frac{48}{19} \le x \le \frac{80}{19}$. The air temperature is between 0°F and 32°F when the altitudes are between $\frac{48}{19}$ and $\frac{80}{19}$ miles inclusively.

(b) The air temperature is between 0°F and 32°F inclusively when the altitude is within $\frac{16}{19}$ mile of $\frac{64}{19}$ miles. $\left|x - \frac{64}{19}\right| \le \frac{16}{19}$.

76. (a) $50 \le 80 - \frac{29}{5}x \le 60 \Rightarrow -30 \le -\frac{29}{5}x \le -20 \Rightarrow \frac{150}{29} \ge x \ge \frac{100}{29} \Rightarrow \frac{100}{29} \le x \le \frac{150}{29}$. The dew point is between 50°F and 60°F when the altitudes are between $\frac{100}{29}$ and $\frac{150}{29}$ miles.

(b) The dew point is between 50°F and 60°F inclusively when the altitude is within $\frac{25}{29}$ mile of $\frac{125}{29}$ miles. $\left|x - \frac{125}{29}\right| \le \frac{25}{29}$.

77. (a) $|T - 43| = 24 \Rightarrow T - 43 = -24$ or $T - 43 = 24 \Rightarrow T = 19$ or $67$. The average monthly temperature range is $19°\text{F} \le T \le 67°\text{F}$.

(b) The monthly average temperatures in Marquette vary between a low of 19°F and a high of 67°F. The monthly averages are always within 24° of 43°F.

78. (a) $|T - 62| = 19 \Rightarrow T - 62 = -19$ or $T - 62 = 19 \Rightarrow T = 43$ or $81$. The average monthly temperature range is $43°\text{F} \le T \le 81°\text{F}$.

(b) The monthly average temperatures in Memphis vary between a low of 43°F and a high of 81°F. The monthly averages are always within 19° of 62°F.

79. (a) $|T - 50| = 22 \Rightarrow T - 50 = -22$ or $T - 50 = 22 \Rightarrow T = 28$ or $72$. The average monthly temperature range is $28°\text{F} \le T \le 72°\text{F}$.

(b) The monthly average temperatures in Boston vary between a low of 28°F and a high of 72°F. The monthly averages are always within 22° of 50°F.

80. (a) $|T - 10| = 36 \Rightarrow T - 10 = -36$ or $T - 10 = 36 \Rightarrow T = -26$ or $46$. The average monthly temperature range is $-26°\text{F} \le T \le 46°\text{F}$.

(b) The monthly average temperatures in Chesterfield vary between a low of –26°F and a high of 46°F. The monthly averages are always within 36° of 10°F.

81. (a) $|T - 61.5| = 12.5 \Rightarrow T - 61.5 = -12.5$ or $T - 61.5 = 12.5 \Rightarrow T = 49$ or $74$. The average monthly temperature range is $49°\text{F} \le T \le 74°\text{F}$.

(b) The monthly average temperatures in Buenos Aires vary between a low of 49°F and a high of 74°F. The monthly averages are always within 12.5° of 61.5°F.

82. (a) $|T - 43.5| = 8.5 \Rightarrow T - 43.5 = -8.5$ or $T - 43.5 = 8.5 \Rightarrow T = 35$ or $52$. The average monthly temperature range is $35°\text{F} \le T \le 52°\text{F}$.

(b) The monthly average temperatures in Punta Arenas vary between a low of 35°F and a high of 52°F. The monthly averages are always within 8.5° of 43.5°F.

83. The solutions to $|d - 3| \le 0.004$ satisfy $s_1 \le d \le s_2$ where $s_1$ and $s_2$ are the solutions to $|d - 3| = 0.004$. $|d - 3| = 0.004$ is equivalent to $d - 3 = -0.004 \Rightarrow d = 2.996$ and $d - 3 = 0.004 \Rightarrow d = 3.004$. The solution set is $\{d | 2.996 \le d \le 3.004\}$. The acceptable diameters are from 2.994 and 3.004 inches.

84. (a) $|L - 12| \le 0.0002$

(b) $-0.0002 \le L - 12 \le 0.0002 \Rightarrow 11.9998 \le L \le 12.0002$; lengths between 11.9998 and 12.0002 inches are acceptable.

85. $\left|\dfrac{Q - A}{A}\right| \le 0.02 \Rightarrow \left|\dfrac{Q - 35}{35}\right| \le 0.02$, so $-0.02 \le \dfrac{Q - 35}{35} \le 0.02 \Rightarrow -0.7 \le Q - 35 \le 0.7 \Rightarrow$ $34.3 \le Q \le 35.7$

86. $\left|\dfrac{P - 50}{50}\right| \le 0.04 \Rightarrow |P - 50| \le 0.04(50)$, then $-2 \le P - 50 \le 2 \Rightarrow 48 \le P \le 52$; therefore, each side would be $P \div 4 \Rightarrow$ lengths between $\dfrac{48}{4} = 12$ and $\dfrac{52}{4} = 13$ feet are acceptable.

## Extended and Discovery Exercises for Section 2.5

1. The distance between points $x$ and $c$ on a number line can be shown by $|x - c|$. This distance is given to be less than some positive value $\delta$. Then $|x - c| < \delta$.

2. The distance between points $f(x)$ and $L$ on a number line can be shown by $|f(x) - L|$. This distance is given to be less than some positive value $\epsilon$. Then $|f(x) - L| < \epsilon$.

## Checking Basic Concepts for Section 2.5

1. $\sqrt{4x^2} = |2x|$

2. $y = |3x - 2|$, then the $x$-value of the vertex is given by $3x - 2 = 0 \Rightarrow 3x = 2 \Rightarrow x = \frac{2}{3}$. Another point is (0, 2). Use symmetry to graph the absolute value function. See Figure 2.

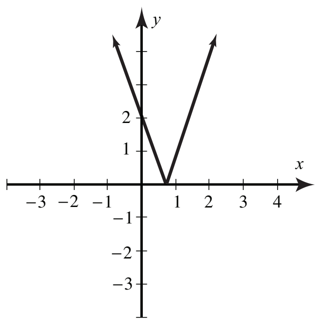


Figure 2

3. (a) Graphically: Graph $Y_1 = \text{abs}(2X - 1)$ and $Y_2 = 5$. Their graphs intersect at the points (–2, 5) and (3,5). The solutions are $-2, 3$. See Figures 3a & 3b.

   Numerically: Table $Y_1 = \text{abs}(2X - 1)$ starting $x$ at –2 and incrementing by 1. The solutions are $-2, 3$. See Figure 3c.

   Symbolically: $|2x - 1| = 5 \Rightarrow 2x - 1 = 5$ or $2x - 1 = -5 \Rightarrow 2x = 6$ or $2x = -4 \Rightarrow x = 3, -2$. The solutions are $-2, 3$.

   (b) The solutions to $|2x - 1| \le 5$ lie between $x = -2$ and $x = 3$, inclusively. Thus, $-2 \le x \le 3$ or $[-2, 3]$. The solutions to $|2x - 1| > 5$ lie left of $x = -2$ or right of $x = 3$. Thus, $x < -2$ or $x > 3$ or $(-\infty, -2) \cup (3, \infty)$.

[–10, 10, 1] by [–10, 10, 1]

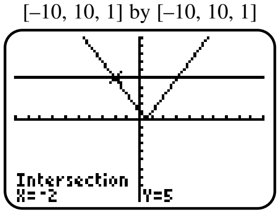


Figure 3a

[–10, 10, 1] by [–10, 10, 1]

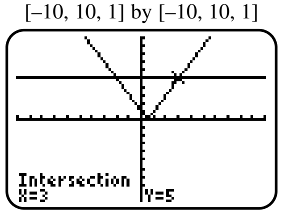


Figure 3b

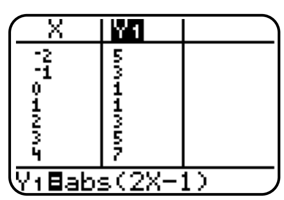


Figure 3c

4. (a) $|2 - 5x| - 4 = -1 \Rightarrow |2 - 5x| = 3 \Rightarrow 2 - 5x = -3$ or $2 - 5x = 3$. If $2 - 5x = -3$, then $-5x = -5 \Rightarrow x = 1$; if $2 - 5x = 3$, then $-5x = 1 \Rightarrow x = -\frac{1}{5} \Rightarrow -\frac{1}{5}, 1$

   (b) The solutions to $|3x - 5| \le 4$ satisfy $s_1 \le x \le s_2$ where $s_1$ and $s_2$, are the solutions to $|3x - 5| = 4$.

   $|3x - 5| = 4$ is equivalent to $3x - 5 = -4 \Rightarrow x = \frac{1}{3}$ or $3x - 5 = 4 \Rightarrow x = 3$.

   The solution set is $\left[\frac{1}{3}, 3\right]$.

   (c) The solutions to $\left|\frac{1}{2}x - 3\right| > 5$ satisfy $x < s_1$ or $x > s_2$ where $s_1$ and $s_2$, are the solutions to $\left|\frac{1}{2}x - 3\right| = 5$.

   $\left|\frac{1}{2}x - 3\right| = 5$ is equivalent to $\frac{1}{2}x - 3 = -5 \Rightarrow x = -4$ or $\frac{1}{2}x - 3 = 5 \Rightarrow x = 16$.

   The solution set is $(-\infty, -4) \cup (16, \infty)$.

5. $|x + 1| = |2x| \Rightarrow x + 1 = 2x$ or $x + 1 = -2x$. If $x + 1 = 2x$, then $x = 1$; $x + 1 = -2x \Rightarrow 1 = -3x \Rightarrow x = -\frac{1}{3}; -\frac{1}{3}, 1$

## Chapter 2 Review Exercises

1. (a) Using the points (0, 6) and (2, 2), $m = \frac{2 - 6}{2 - 0} = \frac{-4}{2} = -2$; $y$-intercept: 6; $x$-intercept: 3.

   (b) $f(x) = -2x + 6$

   (c) The zeros of $f$ are the same as the $x$-intercepts. That is $x = 3$.

2. (a) Using the points (0, –40) and (10, 10), $m = \frac{10 - (-40)}{10 - 0} = \frac{50}{10} = 5$; $y$-intercept: –40; $x$-intercept: 8.

   (b) $f(x) = 5x - 40$

   (c) The zeros of $f$ are the same as the $x$-intercepts. That is $x = 8$.

3. $m = \frac{0 - 2.5}{2 - 1} = \frac{-2.5}{1} = -2.5$; $(1, 2.5) \Rightarrow (1 - 1, 2.5 - (-2.5)) = (0, 5)$, so $b = 5$; $f(x) = -2.5x + 5$

4. $m = \frac{-1.2 - (-1.65)}{6 - (-3)} = \frac{0.45}{9} = 0.05$; since $\frac{0.05}{1} = \frac{0.15}{3}$, $(-3, -1.65) \Rightarrow (-3 + 3, -1.65 + 0.15) = (0, -1.5)$, so $b = -1.5$; $f(x) = 0.05x - 1.5$

5. See Figure 5.

6. See Figure 6.

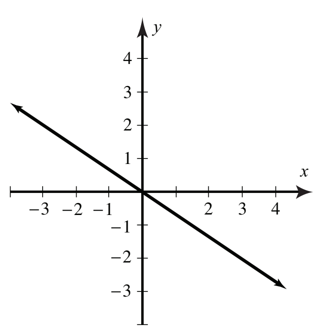


Figure 5

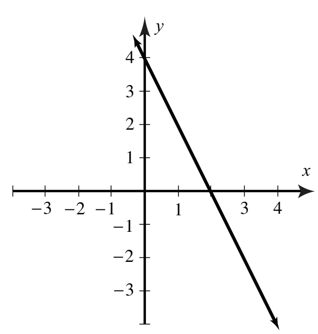


Figure 6

7. Using point-slope form $y = m(x - x_1) + y_1$, we get $y = -2(x + 2) + 3 \Rightarrow f(x) = -2x - 1$

8. $f(-2) = -3(-2) + 8 = 14$ or point $(-2, 14)$; $f(3) = -3(3) + 8 = -1$ or point $(3, -1)$. Find the slope of the line joining these points: $m = \dfrac{-1 - 14}{3 - (-2)} = \dfrac{-15}{5} = -3$; the average rate of change is $-3$.

9. $y = 7(x + 3) + 9 \Rightarrow y = 7x + 21 + 9 \Rightarrow y = 7x + 30$

10. $m = \dfrac{-3 - (-4)}{7 - 2} = \dfrac{1}{5}$; $y = \dfrac{1}{5}(x - 2) - 4 \Rightarrow y = \dfrac{1}{5}x - \dfrac{22}{5}$

11. Let $m = -3$. Then, $y = -3(x - 1) - 1 \Rightarrow y = -3x + 2$.

12. Let $m = -\dfrac{1}{2}$. Then, $y = -\dfrac{1}{2}(x + 2) + 1 \Rightarrow y = -\dfrac{1}{2}x$.

13. The line segment has slope $m = \dfrac{0 - 3.1}{5.7 - 0} = -\dfrac{31}{57}$; the parallel line has slope $m = -\dfrac{31}{57}$;

$y = -\dfrac{31}{57}(x - 1) - 7 \Rightarrow y = -\dfrac{31}{57}x - \dfrac{368}{57}$

14. The given line has slope $m = -\dfrac{5}{7}$; the perpendicular line has slope $m = \dfrac{7}{5}$;

$y = \dfrac{7}{5}\left(x - \dfrac{6}{7}\right) + 0 \Rightarrow y = \dfrac{7}{5}x - \dfrac{6}{5}$

15. The line is vertical passing through (6, –7), so the equation is $x = 6$.

16. The line is horizontal passing through (–3, 4), so the equation is $y = 4$.

17. The line is horizontal passing through (1, 3), so the equation is $y = 3$.

18. The line is vertical passing through (1.5, 1.9), so the equation is $x = 1.5$.

19. The equation of the vertical line with $x$-intercept 2.7 is $x = 2.7$.

20. The equation of the horizontal line with $y$-intercept –8 is $y = -8$.

21. For $x$-intercept: $y = 0 \Rightarrow 5x - 4(0) = 20 \Rightarrow 5x = 20 \Rightarrow x = 4$; for $y$-intercept: $x = 0 \Rightarrow$ $5(0) - 4y = 20 \Rightarrow -4y = 20 \Rightarrow y = -5$; use $(4, 0)$ and $(0, -5)$ to graph the equation. See Figure 21.

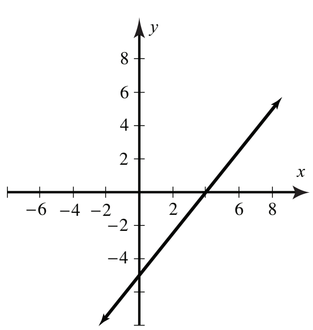



Figure 21

22. For $x$-intercept: $y = 0 \Rightarrow \frac{x}{3} - \frac{0}{2} = 1 \Rightarrow \frac{x}{3} = 1 \Rightarrow x = 3$; for $y$-intercept: $x = 0 \Rightarrow \frac{0}{3} - \frac{y}{2} = 1 \Rightarrow$ $-\frac{y}{2} = 1 \Rightarrow y = -2$; use $(3, 0)$ and $(0, -2)$ to graph the equation. See Figure 22.

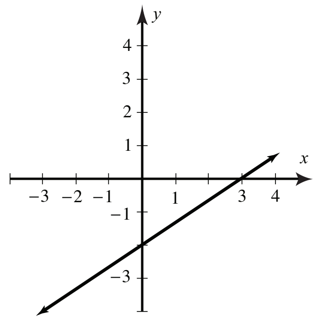



Figure 22

[–15, 15, 5] by [–15, 15, 5]

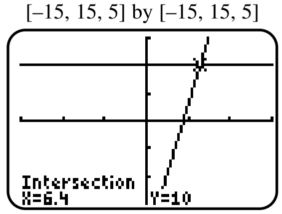



Figure 23

23. Graphical: Graph $Y_1 = 5X - 22$ and $Y_2 = 10$. Their graphs intersect at (6.4, 10) as shown in Figure 23. The solution is $x = 6.4$.

    Symbolic: $5x - 22 = 10 \Rightarrow 5x = 32 \Rightarrow x = \frac{32}{5} = 6.4$

24. Graphical: Graph $Y_1 = 5(4 - 2X)$ and $Y_2 = 16$. Their graphs intersect at (0.4, 16) as shown in Figure 24. The solution is $x = 0.4$.

    Symbolic: $5(4 - 2x) = 16 \Rightarrow 20 - 10x = 16 \Rightarrow 4 = 10x \Rightarrow x = \frac{2}{5} = 0.4$

25. Graphical: Graph $Y_1 = -2(3X - 7) + X$ and $Y_2 = 2X - 1$. Their graphs intersect near (2.143, 3.286) as shown in Figure 25. The solution is approximately 2.143.

    Symbolic: $-2(3x - 7) + x = 2x - 1 \Rightarrow -6x + 14 + x = 2x - 1 \Rightarrow -7x = -15 \Rightarrow x = \frac{15}{7} \approx 2.143$

[–20, 20, 5] by [–10, 20, 5]

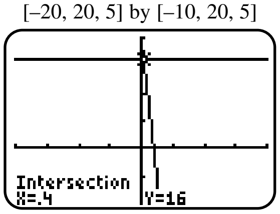



Figure 24

[–10, 10, 1] by [–10, 10, 1]

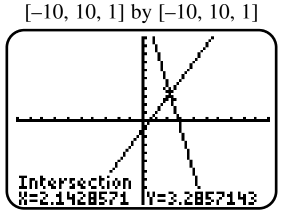



Figure 25

[–10, 10, 1] by [–10, 10, 1]

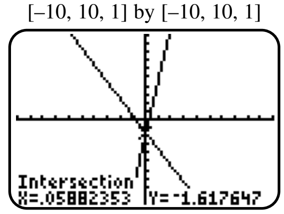



Figure 26

[–10, 10, 1] by [–10, 10, 1]

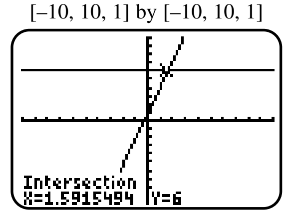



Figure 27

26. Graphical: Graph $Y_1 = 5X - 0.5(4 - 3X)$ and $Y_2 = 1.5 - (2X + 3)$. Their graphs intersect near (0.059, –1.618) as shown in Figure 26. The solution is approximately 0.059.

    Symbolic: $5x - \frac{1}{2}(4 - 3x) = \frac{3}{2} - (2x + 3) \Rightarrow 10x - (4 - 3x) = 3 - 2(2x + 3) \Rightarrow$

    $10x - 4 + 3x = 3 - 4x - 6 \Rightarrow 17x = 1 \Rightarrow x = \frac{1}{17} \approx 0.059$

27. Graphical: Graph $Y_1 = \pi X + 1$ and $Y_2 = 6$. Their graphs intersect near (1.592, 6) as shown in Figure 27. The solution is approximately 1.592.

    Symbolic: $\pi x + 1 = 6 \Rightarrow \pi x = 5 \Rightarrow x = \frac{5}{\pi} \approx 1.592$

28. Graphical: Graph $Y_1 = (X - 4)/2$ and $Y_2 = X + (1 - 2X)/3$. Their graphs intersect at (14, 5) as shown in Figure 28. The solution is 14.

Symbolic: $\dfrac{x-4}{2} = x + \dfrac{1-2x}{3} \Rightarrow 3(x-4) = 6x + 2(1-2x) \Rightarrow 3x - 12 = 6x + 2 - 4x \Rightarrow$ $-14 = -x \Rightarrow x = 14$

29. Let $Y_1 = 3.1X - 0.2 - 2(X - 1.7)$ and approximate where $Y_1 = 0$. From Figure 29 this occurs when $x \approx -2.9$.

[5, 20, 5] by [0, 10, 1]

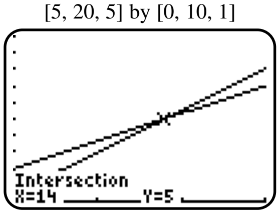



Figure 28

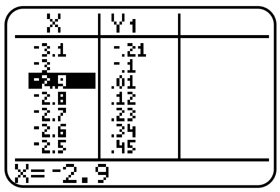



Figure 29

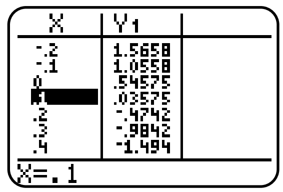



Figure 30

[–10, 10, 1] by [–10, 10, 1]

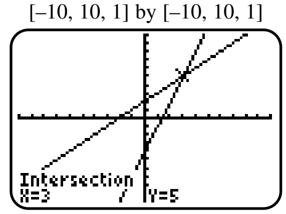



Figure 39

30. Let $Y_1 = \sqrt{(7)} - 3X - 2.1(1 + X)$ and approximate where $Y_1 = 0$. From Figure 30 this occurs when $x \approx 0.1$.

31. (a) $4(6 - x) = -4x + 24 \Rightarrow 24 - 4x = -4x + 24 \Rightarrow 0 = 0 \Rightarrow$ all real numbers are solutions.

(b) Because all real numbers are solutions, the equation is an identity.

32. (a) $\dfrac{1}{2}(4x - 3) + 2 = 3x - (1 + x) \Rightarrow 2x + \dfrac{1}{2} = 2x - 1 \Rightarrow \dfrac{1}{2} = -1 \Rightarrow$ no solutions.

(b) When an equation has no solutions, it is a contradiction.

33. (a) $5 - 2(4 - 3x) + x = 4(x - 3) \Rightarrow 5 - 8 + 6x + x = 4x - 12 \Rightarrow 7x - 3 = 4x - 12 \Rightarrow$ $3x = -9 \Rightarrow x = -3$

(b) Because there are finitely many solutions, the equation in condtional.

34. (a) $\dfrac{x-3}{4} + \dfrac{3}{4}x - 5(2 - 7x) = 36x - \dfrac{43}{4} \Rightarrow \dfrac{x-3}{4} + \dfrac{3}{4}x - 10 + 35x = 36x - \dfrac{43}{4} \Rightarrow$ $x - 3 + 3x - 40 + 140x = 144x - 43 \Rightarrow 144x - 43 = 144x - 43 \Rightarrow 0 = 0 \Rightarrow$ all real numbers are solutions.

(b) Because all real numbers are solutions, the equation is an identity.

35. $(-3, \infty)$

36. $(-\infty, 4]$

37. $\left[-2, \dfrac{3}{4}\right)$

38. $(-\infty, -2] \cup (3, \infty)$

39. Graphical: Graph $Y_1 = 3X - 4$ and $Y_2 = 2 + X$. Their graphs intersect at (3, 5). The graph of $Y_1$ is below the graph of $Y_2$ to the left of the point of intersection. Thus, $3x - 4 \le 2 + x$ holds when $x \le 3$ or $(-\infty, 3]$. See Figure 39. Symbolic: $3x - 4 \le 2 + x \Rightarrow 2x \le 6 \Rightarrow x \le 3$ or $(-\infty, 3]$. In set-builder notation, the interval is $\{x \mid x \le 3\}$.

40. Graphical: Graph $Y_1 = -2X + 6$ and $Y_2 = -3X$. Their graphs intersect at (–6, 18). The graph of $Y_1$ is below the graph of $Y_2$ to the left of the point of intersection. Thus, $-2x + 6 \le -3x$ holds when $x \le -6$ or $(-\infty, -6]$. See Figure 40. Symbolic: $-2x + 6 \le -3x \Rightarrow x \le -6$ or $(-\infty, -6]$. In set-builder notation the interval is $\{x \mid x \le -6\}$.

41. Graphical: Graph $Y_1 = (2X - 5)/2$ and $Y_2 = (5X + 1)/5$. Their graphs are parallel and never intersect. The graph of $Y_1$ is always below the graph of $Y_2$, so $Y_1 < Y_2$ for all values of $x$; the inequality $\frac{2x - 5}{2} < \frac{5x + 1}{5}$ holds when $-\infty < x < \infty$, or $(-\infty, \infty)$. See Figure 41. In set-builder notation the interval is $\{x \mid -\infty < x < \infty\}$.

[–30, 30, 5] by [–30, 30, 5]

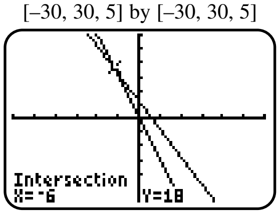



Figure 40

[–10, 10, 1] by [–10, 10, 1]

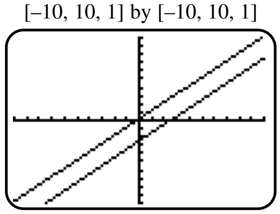


Figure 41

[–5, 5, 1] by [–30, 5, 5]

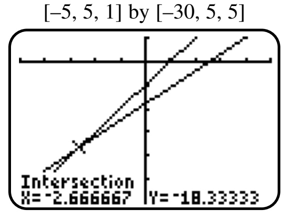



Figure 42

[–10, 10, 1] by [–10, 10, 1]

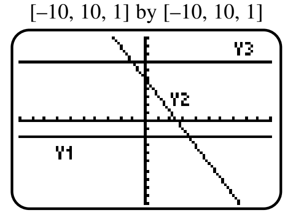



Figure 43

42. Graphical: Graph $Y_1 = -5(1 - X)$ and $Y_2 = 3(X - 3) + 0.5X$. Their graphs intersect near (–2.6667, –18.3333). The graph of $Y_1$ is above the graph of $Y_2$ to the right of the point of intersection. Thus, $-5(1 - x) > 3(x - 3) + \frac{1}{2}x$ holds when $x > -2.6667$ or $\left(-\frac{8}{3}, \infty\right)$. See Figure 42.

Symbolic: $-5(1 - x) > 3(x - 3) + \frac{1}{2}x \Rightarrow -5 + 5x > 3x - 9 + \frac{1}{2}x \Rightarrow \frac{3}{2}x > -4 \Rightarrow x > -\frac{8}{3}$, or $\left(-\frac{8}{3}, \infty\right)$. In set-builder notation, the interval is $\left\{x \mid x > -\frac{8}{3}\right\}$.

43. Graphical: Graph $Y_1 = -2$, $Y_2 = 5 - 2X$ and $Y_3 = 7$. See Figure 43. Their graphs intersect at the points (–1, 7) and (3.5, –2). The graph of $Y_2$ is between the graphs of $Y_1$ and $Y_3$ when $-1 < x \le 3.5$. In interval notation the solution is (–1, 3.5].

Symbolic: $-2 \le 5 - 2x < 7 \Rightarrow -7 \le -2x < 2 \Rightarrow \frac{7}{2} \ge x > -1 \Rightarrow -1 < x \le \frac{7}{2}$ or $\left(-1, \frac{7}{2}\right]$

In set-builder notation, the interval is $\left\{x \mid -1 < x \le \frac{7}{2}\right\}$.

44. Graphical: Graph $Y_1 = -1$, $Y_2 = (3X - 5)/-3$, and $Y_3 = 3$. See Figure 44. Their graphs intersect at the points $\left(-\frac{4}{3}, 3\right)$ and $\left(\frac{8}{3}, -1\right)$. The graph of $Y_2$ is between the graphs of $Y_1$ and $Y_3$ when $-\frac{4}{3} < x < \frac{8}{3}$. In interval notation the solution is $\left(-\frac{4}{3}, \frac{8}{3}\right)$. Symbolic: $-1 < \frac{3x - 5}{-3} < 3 \Rightarrow 3 > 3x - 5 > -9 \Rightarrow$ $-9 < 3x - 5 < 3 \Rightarrow -4 < 3x < 8 \Rightarrow \left(-\frac{4}{3}, \frac{8}{3}\right)$. In set-builder notation the soultion set is $\left\{x \middle| -\frac{4}{3} < x < \frac{8}{3}\right\}$.

45. Graph $Y_1 = 2x$ and $Y_2 = x - 1$. See Figure 45. The lines intersect at $(-1, -2)$. $Y_1 > Y_2$ when the graph of $Y_1$ is above the graph of $Y_2$; this happens when $x > -1 \Rightarrow (-1, \infty)$. In set-builder notation the interval is $\{x | x > -1\}$.

[–10, 10, 1] by [–10, 10, 1]

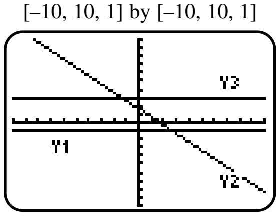



Figure 44

[–10, 10, 1] by [–10, 10, 1]

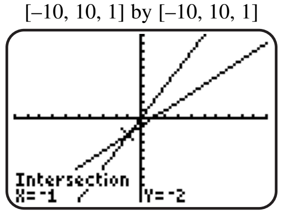



Figure 45

[–10, 10, 1] by [–10, 10, 1]

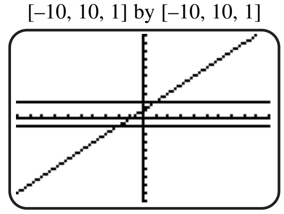


Figure 46

46. Graph $Y_1 = -1$, $Y_2 = 1 + x$ and $Y_3 = 2$. See Figure 46. The two points of intersection are $(-2, -1)$ and $(1, 2)$. $Y_1 \leq Y_2 \leq Y_3$ when the graph of $1 + x$ is between these two intersection points $\Rightarrow$ $-2 \leq x \leq 1 \Rightarrow [-2, 1]$.

47. (a) The graphs intersect at (2, 1). The solution to $f(x) = g(x)$ is 2.
    (b) The graph of $f$ is below the graph of $g$ to the right of (2, 1).
    Thus, $f(x) < g(x)$ when $x > 2$ or on $(2, \infty)$.
    (c) The graph of $f$ is above the graph of $g$ to the left of (2, 1). Thus, $f(x) > g(x)$ when $x < 2$ or on $(-\infty, 2)$.

48. (a) The graphs of $f$ and $g$ intersect at (6, 2). The solution to $f(x) = g(x)$ is 6.
    (b) The graphs of $g$ and $h$ intersect at (2, 4). The solution to $f(x) = g(x)$ is 2.
    (c) The graph of $g$ is between the graphs of $f$ and $h$ when $2 < x < 6$. Thus, $f(x) < g(x) < h(x)$ when $x$ is in the interval (2, 6).
    (d) The graph of $g$ is above the graph of $h$ to the left of the point (2, 4). Thus, $g(x) > h(x)$ when $x$ is in the interval [0, 2). (Remember: $D = \{x | 0 \leq x \leq 7\}$.)

49. (a) $f(-2) = 8 + 2(-2) = 4$; $f(-1) = 8 + 2(-1) = 6$; $f(2) = 5 - 2 = 3$; $f(3) = 3 + 1 = 4$.
    (b) The graph of $f$ is shown in Figure 49. It is essentially a piecewise line graph with the points (–3, 2), (–1, 6), (2, 3), and (5, 6). Since there are no breaks in the graph, $f$ is continuous.
    (c) From the graph we can see that there are two $x$-values where $f(x) = 3$. They occur when $8 + 2x = 3 \Rightarrow x = -2.5$ and when $5 - x = 3 \Rightarrow x = 2$. The solutions are $x = -2.5$ or 2.

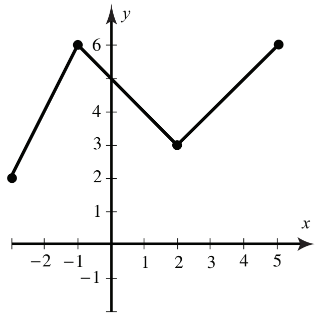



Figure 49

50. $f(-3.1) = [\![2(-3.1) - 1]\!] = [\![-7.2]\!] = -8$ and $f(2.5) = [\![2(2.5) - 1]\!] = [\![4]\!] = 4$

51. $|2x - 5| - 1 = 8 \Rightarrow |2x - 5| = 9 \Rightarrow 2x - 5 = -9$ or $2x - 5 = 9$; $2x - 5 = -9 \Rightarrow 2x = -4 \Rightarrow$ $x = -2$; $2x - 5 = 9 \Rightarrow 2x = 14 \Rightarrow x = 7 \Rightarrow -2, 7$

52. $|3 - 7x| = 10 \Rightarrow 3 - 7x = -10$ or $3 - 7x = 10$; $3 - 7x = -10 \Rightarrow -7x = -13 \Rightarrow x = \frac{13}{7}$; $3 - 7x = 10 \Rightarrow -7x = 7 \Rightarrow x = -1 \Rightarrow -1, \frac{13}{7}$

53. $|6 - 4x| = -2$ has no solutions since the absolute value of any quantity is always greater than or equal to 0.

54. $|9 + x| = |3 - 2x| \Rightarrow 9 + x = 3 - 2x$ or $9 + x = -(3 - 2x)$; $9 + x = 3 - 2x \Rightarrow 3x = -6 \Rightarrow$ $x = -2$; $9 + x = -(3 - 2x) \Rightarrow 9 + x = -3 + 2x \Rightarrow -x = -12 \Rightarrow x = 12 \Rightarrow -2, 12$

55. $|x| = 3 \Rightarrow x = \pm 3$. The solutions to $|x| > 3$ lie to the left of $-3$ and to the right of 3. That is, $x < -3$ or $x > 3$. This can be supported by graphing $Y_1 = |x|$ and $Y_2 = 3$ and determining where the graph of $Y_1$ is above the graph of $Y_2$. To support this result numerically, table $Y_1 = \text{abs}(X)$ starting at –9 and incrementing by 3.

56. $|-3x + 1| = 2 \Rightarrow -3x + 1 = -2$ or $-3x + 1 = 2 \Rightarrow x = 1$ or $-\frac{1}{3}$. The solutions to $|-3x + 1| < 2$ lie between 1 and $-\frac{1}{3}$; that is, $-\frac{1}{3} < x < 1$. This can be supported by graphing $Y_1 = |-3x + 1|$ and $Y_2 = 2$ and determining where the graph of $Y_1$ is below the graph of $Y_2$. To support this result numerically, table $Y_1 = \text{abs}(-3X + 1)$ starting at –1 and incrementing by $\frac{1}{3}$.

57. $|3x - 7| = 10 \Rightarrow 3x - 7 = 10$ or $3x - 7 = -10 \Rightarrow x = \frac{17}{3}$ or $x = -1$. The solutions to $|3x - 7| > 10$ lie to the left of $-1$ or to the right of $x = \frac{17}{3}$; that is, $x < -1$ or $x > \frac{17}{3}$. This can be supported by graphing $Y_1 = |3x - 7|$ and $Y_2 = 10$ and determining where the graph of $Y_1$ is above the graph of $Y_2$. To support this result numerically, table $Y_1 = \text{abs}(3X - 7)$ starting at –3 and incrementing by $\frac{1}{3}$.

58. $|4 - x| = 6 \Rightarrow 4 - x = 6$ or $4 - x = -6 \Rightarrow x = -2$ or $x = 10$. The solutions to $|4 - x| \le 2$ lie between $-2$ and 10, inclusively; that is, $-2 \le x \le 10$. This can be supported by graphing $Y_1 = |4 - x|$ and $Y_2 = 6$ and determining where the graph of $Y_1$ is below the graph of $Y_2$. To support this result numerically, table $Y_1 = \text{abs}(4 - X)$ starting at –6 and incrementing by 4.

59. The solutions to $|3 - 2x| < 9$ satisfy $s_1 < x < s_2$ where $s_1$ and $s_2$, are the solutions to $|3 - 2x| = 9$.

$|3 - 2x| = 9$ is equivalent to $3 - 2x = -9 \Rightarrow x = 6$ or $3 - 2x = 9 \Rightarrow x = -3$.

The solutions are $-3 < x < 6$ or $(-3, 6)$.

60. The solutions to $|-2x - 3| > 3$ satisfy $x < s_1$ or $x > s_2$, where $s_1$ and $s_2$ are the solutions to $|-2x - 3| = 3$.

$|-2x - 3| = 3$ is equivalent to $-2x - 3 = -3 \Rightarrow x = 0$ or $-2x - 3 = 3 \Rightarrow x = -3$.

The solutions are $x < -3$ or $x > 0$ or $(-\infty, -3)\cup(0, \infty)$.

61. The solutions to $\left|\frac{1}{3}x - \frac{1}{6}\right| \geq 1$ satisfy $x \leq s_1$ or $x \geq s_2$ where $s_1$ and $s_2$, are the solutions to $\left|\frac{1}{3}x + \frac{1}{6}\right| = 1$.

$\left|\frac{1}{3}x - \frac{1}{6}\right| = 1$ is equivalent to $\frac{1}{3}x - \frac{1}{6} = -1 \Rightarrow x = -\frac{5}{2}$ or $\frac{1}{3}x - \frac{1}{6} = 1 \Rightarrow x = \frac{7}{2}$.

The solutions are $x \leq -\frac{5}{2}$ or $x \geq \frac{7}{2}$ or $\left(-\infty, -\frac{5}{2}\right]\cup\left[\frac{7}{2}, \infty\right)$.

62. First rewrite the inequality: $\left|\frac{1}{2}x\right| - 3 \leq 5 \Rightarrow \left|\frac{1}{2}x\right| \leq 8$.

The solutions to $\left|\frac{1}{2}x\right| \leq 8$ satisfy $s_1 \leq x \leq s_2$, where $s_1$ and $s_2$ are the solutions to $\left|\frac{1}{2}x\right| = 8$.

$\left|\frac{1}{2}x\right| = 8$ is equivalent to $\frac{1}{2}x = -8 \Rightarrow x = -16$ or $\frac{1}{2}x = 8 \Rightarrow x = 16$. The solutions are $-16 \leq x \leq 16$ or $[-16, 16]$.

63. (a) Graph $Y_1 = 1450(x - 1980) + 20{,}000$ and $Y_2 = 34{,}500$. Their graphs intersect at the point (1990, 34,500). See Figure 63. This means that in 1990 the median income was \$34,500.

(b) $1450(x - 1980) + 20{,}000 = 34{,}500 \Rightarrow 1450(x - 1980) = 14{,}500 \Rightarrow x = \frac{14{,}500}{1450} + 1980 = 1990$

[1980, 2005, 2] by [20000, 40000, 1000]

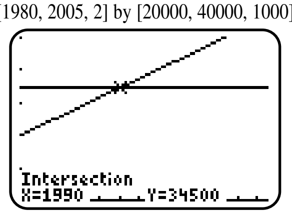



Figure 63

[1995, 2007, 1] by [200, 400, 50]

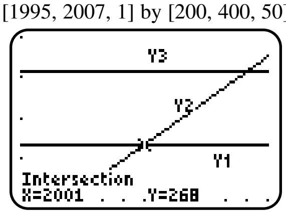



Figure 65a

[1995, 2007, 1] by [200, 400, 50]

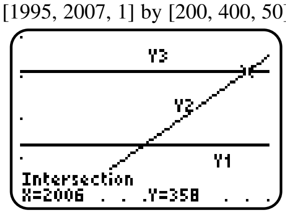



Figure 65b

64. Let $x$ be the minimum score received on the final exam. The total number of points possible in the course is $75 + 75 + 150 = 300$. Moreover, 80% of 300 is 240 points, which would result in a B grade. The minimum score $x$ on the final necessary to receive a B is given by the equation $55 + 72 + x = 240 \Rightarrow x = 113$. A score of 113 or higher will result in a B grade or better.

65. $268 \leq 18x - 35{,}750 \leq 358 \Rightarrow 36{,}018 \leq 18x \leq 36{,}108 \Rightarrow 2001 \leq x \leq 2006$. Medicare costs will be between 268 and 358 billion dollars from 2001 to 2006.

Graph $Y_1 = 268$, $Y_2 = 18X - 35{,}750$, and $Y_3 = 358$. Their graphs intersect at the points (2001, 268) and (2006, 358). See Figures 65a & 65b. Medicare costs will be between 268 and 358 billion dollars from 2001 to 2006.

66. (a) Plot the ordered pairs $(-40, -40)$, $(32, 0)$, $(59, 15)$, $(95, 35)$, and $(212, 100)$. The data appears to be linear. See Figure 66.

(b) We must determine the linear function whose graph passes through these points. To determine its equation we shall use the points $(32, 0)$ and $(212, 100)$, although any pair of points would work. The slope of the graph is $\frac{100 - 0}{212 - 32} = \frac{100}{180} = \frac{5}{9}$. The symbolic representation of this function is $C$ is $C(x) = \frac{5}{9}(x - 32) + 0$ or $C(x) = \frac{5}{9}(x - 32)$. A slope of $\frac{5}{9}$ means that the Celsius temperature changes 5° for every 9° change in the Fahrenheit temperature.

(c) $C(83) = \frac{5}{9}(83 - 32) = 28\frac{1}{3}^{\circ}$ Celsius.

[–50, 250, 50] by [–50, 110, 50]

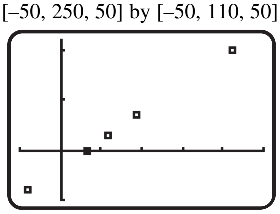


Figure 66

[1988, 1995, 1] by [20.5, 20.9, 0.1]

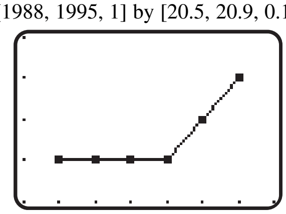


Figure 68

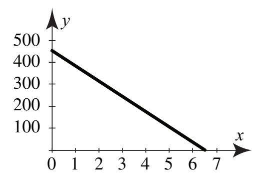



Figure 70

67. Since the graph is piecewise linear, the slope each line segment represents a constant speed. Initially, the car is home. After 1 hour it is 30 miles from home and has traveled at a constant speed of 30 mph. After 2 hours it is 50 miles away. During the second hour the car travels 20 mph. During the third hour the car travels toward home at 30 mph until it is 20 miles away. During the fourth hour the car travels away from home at 40 mph until it is 60 miles away from home. The last hour the car travels 60 miles at 60 mph until it arrives back at home.

68. (a) Make a line graph using the points $(1989, 20.6)$, $(1990, 20.6)$, $(1991, 20.6)$, $(1992, 20.6)$, $(1993, 20.7)$, and $(1994, 20.8)$. See Figure 68.

(b) From $x = 1989$ to $x = 1992$ the function $f$ is constant with $f(x) = 20.6$. From 1992 to 1994 the graph increases with a slope of 0.1. A piecewise-linear function can be defined by

$$f(x) = \begin{cases} 20.6, & \text{if } 1989 \leq x \leq 1992 \\ 0.1(x - 1992) + 20.6, & \text{if } 1992 < x \leq 1994 \end{cases}$$

(c) $[1989, 1994]$

69. The midpoint is computed by $\left(\frac{2004 + 2008}{2}, \frac{143{,}247 + 167{,}933}{2}\right) = (2006, 155{,}590)$.

The population was about 155,590.

70. (a) $f(x) = 455 - 70x$, where $x$ is in hours.

(b) See Figure 70. $D = \{x \mid 0 \leq x \leq 6.5\}$ is an appropriate domain for $f$.

(c) $f(x) = 0 \Rightarrow 0 = 455 - 70x \Rightarrow x = \frac{455}{70} = 6.5$ ($x$-intercept); $f(0) = 455 - 7(0) = 455 \Rightarrow y = 455$ ($y$-intercept); the $x$-intercept indictaes that the driver arrives at home after 6.5 hours, and the $y$-intercept indicates that the driver starts out 455 miles from home.

71. Let $x$ = time it takes for both working together; the first worker can shovel $\frac{1}{50}$ of the sidewalk in 1 minute, and the second worker can shovel $\frac{1}{30}$ of the sidewalk in 1 minute; for the entire job, we get the equation $\frac{x}{50} + \frac{x}{30} = 1 \Rightarrow 3x + 5x = 150 \Rightarrow 8x = 150 \Rightarrow x = 18.75$; it takes the two workers 18.75 minutes to shovel the sidewalk together.

72. Let $x$ = number of gallons of the 80% antifreeze solution; then $20 + x$ = number of gallons of the final 50% antifreeze solution; the amount of antifreeze in the 30% and 80% solutions equals the amount of antifreeze in the 50% solution: $0.30(20) + 0.80x = 0.50(20 + x) \Rightarrow 3(20) + 8x = 5(20 + x) \Rightarrow$ $60 + 8x = 100 + 5x \Rightarrow 3x = 40 \Rightarrow x = \frac{40}{3} = 13\frac{1}{3}$; $13\frac{1}{3}$ gallons of the 80% antifreeze solution should be added.

73. Let $t$ = time spent jogging at 7 mph; then $1.8 - t$ = time spent jogging at 8 mph; since $d = rt$ and the total distance jogged is 13.5 miles, we get the equation $7t + 8(1.8 - t) = 13.5 \Rightarrow 7t + 14.4 - 8t = 13.5 \Rightarrow$ $-t = -0.9 \Rightarrow t = 0.9$ and $1.8 - t = 0.9$; the runner jogged 0.9 hour at 7 mph and 0.9 hour at 8 mph.

74. (a) The scatterplot in Figure 74 of the points (1960, 1394), (1970, 1763), (1980, 3176), (1990, 5136), and (2000, 6880) indicates that the correlation coefficient should be positive, and somewhat close to 1.

(b) $y = ax + b$, where $a = 143.45$ and $b \approx -280{,}361.2 \Rightarrow y = 143.45x - 280{,}361.2$; $r \approx 0.978$

(c) $y = 143.45(1995) - 280{,}361.2 \approx 5821.55$; the estimated cost of driving a mid-size car in 1995 was \$5821.55.

(d) $8000 = 143.45x - 280{,}361.2 \Rightarrow 288{,}361.2 = 143.45x \Rightarrow x \approx 2010.186$. Therefore, in the year 2010 the cost will be \$8000.

[1955, 2005, 10] by [1000, 7000, 1000]

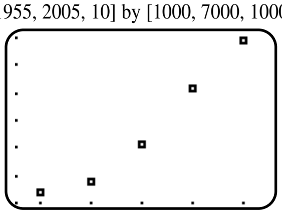


Figure 74

75. (a) Begin by selecting any two points to determine the equation of the line. For example, if we use $(-1, 4.2)$ and $(2, 0.6)$, then $m = \frac{4.2 - 0.6}{-1 - 2} = \frac{3.6}{-3} = -1.2$. $y - y_1 = m(x - x_1) \Rightarrow y - 0.6 = -1.2(x - 2) \Rightarrow$ $y - 0.6 = -1.2x + 2.4 \Rightarrow y = -1.2x + 3$.

(b) When $x = -1.5$, then $y = -1.2(-1.5) + 3 = 4.8$. This involves interpolation.

When $x = 3.5$, then $y = -1.2(3.5) + 3 = -1.2$. This involves extrapolation.

(c) $1.3 = -1.2x + 3 \Rightarrow -1.7 = -1.2x \Rightarrow x = \frac{17}{12}$.

76. Let $x =$ width of rectangle; then $2x =$ length of the rectangle; $P = 78$ inches and $P = 2w + 2l \Rightarrow$ $2x + 2(2x) = 78 \Rightarrow 2x + 4x = 78 \Rightarrow 6x = 78 \Rightarrow x = 13$ and $2x = 26$; the rectangle is 13 inches by 26 inches.

77. The tank is initially empty. When $0 \le x \le 3$, the slope is 5. The inlet pipe is open; the outlet pipe is closed. When $3 < x \le 5$, the slope is 2. Both pipes are open. When $5 < x \le 8$, the slope is 0. Both pipes are closed. When $8 < x \le 10$, the slope is –3. The inlet pipe is closed; the outlet pipe is open.

78. The tank initially contains 25 gallons.

On the interval [0, 4], the slope is 5. The 5 gal/min inlet pipe is open. The other pipes are closed.

On the interval (4, 8], the slope is –3 . Both inlet pipes are closed. The outlet pipe is open.

On the interval (8, 12], the slope is 7. Both inlet pipes are open. The outlet pipe is closed.

On the interval (12, 16], the slope is 4. All pipes are open.

On the interval (16, 24], the slope is –1. The 2 gal/min inlet pipe and the outlet pipe are open.

On the interval (24, 28], the slope is 0. All pipes are closed.

79. Let $x$ represent the distance above the ground and let $y$ represent the temperature. Since the ground temperature is 25ºC, the point (0, 25) is on the graph of the function which models the situation. Since the rate of change is a constant –6ºC per kilometer, the model is linear with a slope of $m = -6$. Therefore, the equation of the linear model is $y = -6x + 25$.

Graphically: Graph $Y_1 = 15$, $Y_2 = -6x + 25$, and $Y_3 = 5$ in $[0, 4, 1]$ by $[0, 30, 5]$. See Figure 79. The intersection points are $\left(1\frac{2}{3}, 15\right)$ and $\left(3\frac{1}{3}, 5\right)$. The distance above the ground is between $1\frac{2}{3}$ km and $3\frac{1}{3}$ km.

Symbolically: Solve $5 \le -6x + 25 \le 15 \Rightarrow -20 \le -6x \le -10 \Rightarrow \frac{20}{6} \ge x \ge \frac{10}{6} \Rightarrow 1\frac{2}{3} \le x \le 3\frac{1}{3}$.

The solution interval is the same for either method, $\left[1\frac{2}{3}, 3\frac{1}{3}\right]$. The distance above the ground is between $1\frac{2}{3}$ km and $3\frac{1}{3}$ km.

[0, 4, 1] by [0, 30, 5]

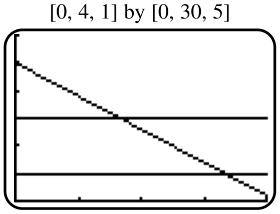


Figure 79

80. (a) $6.15x - 12{,}059 > 70 \Rightarrow 6.15x > 12{,}129 \Rightarrow x > 1972.20$; the number of species first exceeded 70 in 1972.

(b) $50 \leq 6.15x - 12{,}059 \leq 100 \Rightarrow 12{,}109 \leq 6.15x \Rightarrow 12{,}159 \Rightarrow 1968.94 \leq x \leq 1977.07$. From 1969 to 1977, the number of species was between 50 and 100.

81. $\left|\dfrac{C - A}{A}\right| \leq 0.003 \Rightarrow -0.003 \leq \dfrac{C - 52.3}{52.3} \leq 0.003 \Rightarrow -0.1569 \leq C - 52.3 \leq 0.1569 \Rightarrow$

$52.1431 \leq C \leq 52.4569 \Rightarrow$ between 52.1431 and 52.4569 ft.

82. (a) Because $1940 \leq 1947 \leq 1960$, $f(1947)$ is calculated using the formula

$f(1947) = \dfrac{11}{20}(1947 - 1940) + 7 = 10.85\%$. Similarly, $f(1972)$ is found using the second formula

$f(1972) = \dfrac{32}{15}(1972 - 1960) + 18 = 43.6\%$.

(b) See Figure 82.

(c) The graph has no breaks, so $f$ is continuous on its domain.

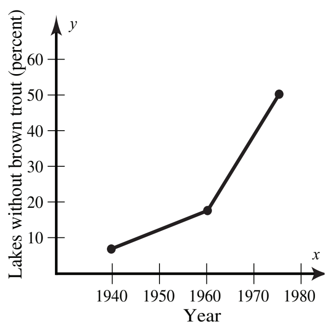


Figure 82

## Extended and Discovery Exercises for Chapter 2

1. (a) 62.8 inches

(b) The $(x, y)$ pairs for females are plotted in Figure 1a and for males in Figure 1b. Both sets of data appear to be linear.

(c) Female: 3.1 inches; male: 3.0 inches

(d) $f(x) = 3.1(x - 8) + 50.4$; $g(x) = 3.0(x - 8) + 53$

(e) $f(9.7) = 55.67$ and $f(10.1) = 56.91$. For a female, the height could vary between 55.67 and 56.91 inches.

$g(9.7) = 58.1$ and $g(10.1) = 59.3$. For a male, the height could vary between 58.1 and 59.3 inches.

[7, 15, 1] by [45, 75, 5]

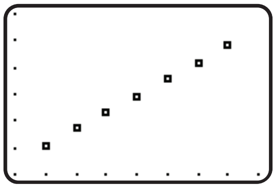


Figure 1a

[7, 15, 1] by [45, 75, 5]

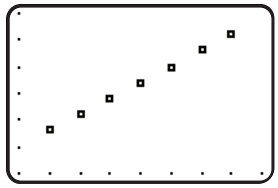


Figure 1b

2. *Answers may vary.*

3. Let $x$ represent the distance walked by the 1st person. Let $z$ represent the distance walked by the 2nd person.

   Let $y$ represent the distance the car travels between dropping off the 2nd person and picking up the 1st person.

   Refer to Figure 3.

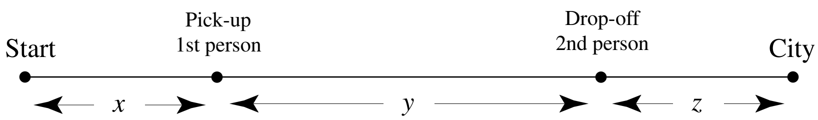



Figure 3

Using the formula time $= \dfrac{\text{distance}}{\text{rate}}$ we obtain the following results:

(1) (time for 1st person to walk distance $x$) = (time for car to drive distance $x + 2y$) $\Rightarrow \dfrac{x}{4} = \dfrac{x + 2y}{28} \Rightarrow$

$28x = 4x + 8y \Rightarrow 24x = 8y \Rightarrow 3x = y.$

(2) (time for 2nd person to walk distance $z$) = (time for car to drive distance $2y + z$) $\Rightarrow \dfrac{z}{4} = \dfrac{2y + z}{28} \Rightarrow$

$28z = 8y + 4z \Rightarrow 24z = 8y \Rightarrow 3z = y.$

(3) The total distance is 15 miles. Thus, $x + y + z = 15.$

Solving these three equations simultaneously results in $x = 3, y = 9, z = 3$. Each person walked 3 miles.

4. This problem can be solved using ratios; $\dfrac{200 \times 10^6}{4.45 \times 10^9} \approx 0.045$, so dinosaurs appeared 4.5% of the time before midnight December 31. 4.5% of 365 days is approximately 16.4 days; this corresponds to approximately December 15 at 2:24 P.M. Similarly, Homo sapiens first lived approximately $\dfrac{300 \times 10^3}{4.45 \times 10^9} \approx 0.000067$ or 0.0067% of the time before midnight December 31. $0.0067\% \times 365 \approx 0.025$ day. Since there are twenty-four hours in a day, this is equal to $0.025 \times 24 = 0.59$ hour or approximately 35 minutes before midnight. Thus, dinosaurs would have appeared on December 15 at 2:24 P.M., while Homo sapiens would have appeared on December 31 at 11:25 P.M.

5. If $|x - c| < \delta$, then $|f(x) - L| < \epsilon$.

## Chapters 1-2 Cumulative Review Exercises

1. Move the decimal point five places to the left; $123{,}000 = 1.23 \times 10^5$

   Move the decimal point three places to the right; $0.005 = 5.1 \times 10^{-3}$

2. Move the decimal point six places to the right; $6.7 \times 10^6 = 6{,}700{,}000$

   Move the decimal point four places to the left; $1.45 \times 10^{-4} = 0.000145$

3. $\dfrac{4 + \sqrt{2}}{4 - \sqrt{2}} \approx 2.09$

4. (a) Yes, each input has only one output.

   (b) $D = \{-1, 0, 1, 2, 3\}$; $R = \{0, 3, 4, 6\}$

5. The standard equation of a circle must fit the form $(x - h)^2 + (y - k)^2 = r^2$, where $(h, k)$ is the center and the radius $r$. The equation of the circle with center (–2, 3) and radius 7 is $(x + 2)^2 + (y - 3)^2 = 49$.

6. $-5^2 - 2 - \dfrac{10 - 2}{5 - 1} = -25 - 2 - \dfrac{8}{4} = -25 - 2 - 2 = -29$

7. $d = \sqrt{[2 - (-3)]^2 + ((-3) - 5)^2} = \sqrt{25 + 64} = \sqrt{89}$

8. Midpoint $= \left(\dfrac{5 + (-3)}{2}, \dfrac{-2 + 1}{2}\right) = \left(\dfrac{2}{2}, \dfrac{-1}{2}\right) = \left(1, -\dfrac{1}{2}\right)$

9. (a) $D =$ all real numbers $\Rightarrow \{x \mid -\infty < x < \infty\}$; $R = \{y \mid y \geq -2\}$; $f(-1) = -1$

   (b) $D = \{x \mid -3 \leq x \leq 3\}$; $R = \{y \mid -3 \leq y \leq 2\}$; $f(-1) = -\dfrac{1}{2}$

10. (a) See Figure 10a.

    (b) See Figure 10b.

    (c) See Figure 10c.

    (d) See Figure 10d.

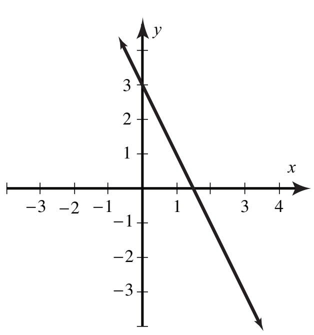


Figure 10a

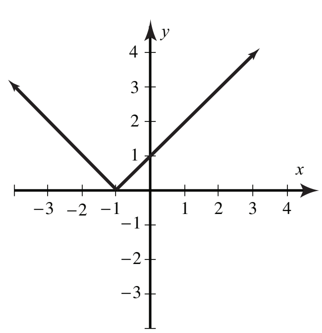


Figure 10b

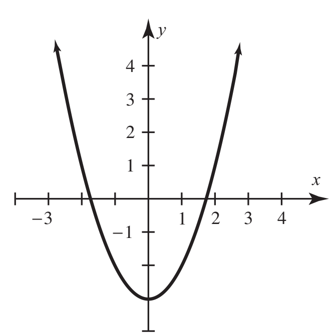


Figure 10c

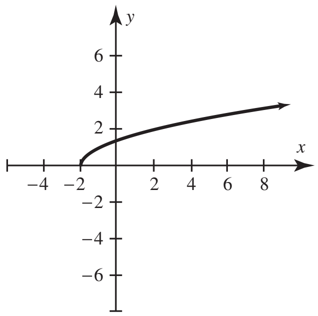



Figure 10d

11. (a) $f(2) = 5(2) - 3 = 7;\ f(a-1) = 5(a-1) - 3 = 5a - 5 - 3 = 5a - 8$

    (b) The domain of $f$ includes all real numbers $\Rightarrow D = \{x \mid -\infty \le x \le \infty\}$

12. (a) $f(2) = \sqrt{2(2)-1} = \sqrt{3};\ f(a-1) = \sqrt{2(a-1)-1} = \sqrt{2a-2-1} = \sqrt{2a-3}$

    (b) The domain of $f$ includes all real numbers greater than or equal to $\frac{1}{2} \Rightarrow D = \left\{x \middle| x \ge \frac{1}{2}\right\}$.

13. No, this is not a graph of a function because some vertical lines intersect the graph twice.

14. $f(x) = 80x + 89$

15. $f(1) = (1)^2 - 2(1) + 1 = 1 - 2 + 1 = 0 \Rightarrow (1, 0);\ f(2) = (2)^2 - 2(2) + 1 = 4 - 4 + 1 = 1 \Rightarrow$ (2, 1). The slope $m = \frac{1-0}{2-1} = \frac{1}{1} = 1$, so the average rate of change is 1.

16. $f(x) = 2x^2 - x;\ f(x+h) = 2(x+h)^2 - (x+h) = 2x^2 + 4xh + 2h^2 - x - h$. The difference quotient

$$= \frac{f(x+h) - f(x)}{h} = \frac{2x^2 + 4xh + 2h^2 - x - h - (2x^2 - x)}{h} = \frac{4xh + 2h^2 - h}{h} = 4x + 2h - 1$$

17. (a) $m = \frac{2}{3}$; $y$-intercept: $-2$, $x$-intercept: 3

    (b) $f(x) = mx + b \Rightarrow f(x) = \frac{2}{3}x - 2$

    (c) 3

18. (a) $m = -\frac{4}{3}$; $y$-intercept: 2; $x$-intercept: $\frac{3}{2}$

    (b) $f(x) = mx + b \Rightarrow f(x) = -\frac{4}{3}x + 2$

    (c) $\frac{3}{2}$

19. Using point-slope form

$$y = m(x - x_1) + y_1 \Rightarrow y = -3\left(x - \frac{2}{3}\right) - \frac{2}{3} \Rightarrow y = -3x + \frac{4}{3} \Rightarrow f(x) = -3x + \frac{4}{3}$$

20. The tank initially contains 200 gallons of water and the amount of water is decreasing at a rate of 10 gallons per minute.

21. $m = \dfrac{\frac{1}{2} - (-5)}{-3 - 1} = \dfrac{\frac{11}{2}}{-4} = -\dfrac{11}{8}$; using $(1, -5)$ and point-slope form: $y = -\dfrac{11}{8}(x - 1) - 5 \Rightarrow$

$y = -\dfrac{11}{8}x + \dfrac{11}{8} - 5 \Rightarrow y = -\dfrac{11}{8}x - \dfrac{29}{8}$

22. If the line is perpendicular to $y = \dfrac{2}{3}x - 7$ which has a slope of $\dfrac{2}{3}$, then its slope is $-\dfrac{3}{2}$.

Using point-slope form: $y = -\dfrac{3}{2}(x + 3) + 2 \Rightarrow y = -\dfrac{3}{2}x - \dfrac{5}{2}$

23. All lines parallel to the $y$-axis have undefined slope $\Rightarrow$ $y$ changes but $x$ remains constant $\Rightarrow x = -1$.

24. Using point-slope form $y = 30(x - 2002) + 50 \Rightarrow y = 30x - 60{,}010$

25. For the points $(2.4, 5.6)$ and $(3.9, 8.6)$ we get $m = \dfrac{8.6 - 5.6}{3.9 - 2.4} = \dfrac{3}{1.5} = 2$. A line parallel to this has the same slope. Using point-slope form: $y = 2(x + 3) + 5 \Rightarrow y = 2x + 11$.

26. Lines perpendicular to the $y$-axis have slope $0 \Rightarrow y = 0$.

27. For $-2x + 3y = 6$: $x$-intercept, then $y = 0 \Rightarrow -2x + 3(0) = 6 \Rightarrow -2x = 6 \Rightarrow x = -3$;

$y$-intercept, then $x = 0 \Rightarrow -2(0) + 3y = 6 \Rightarrow 3y = 6 \Rightarrow y = 2$. See Figure 27.

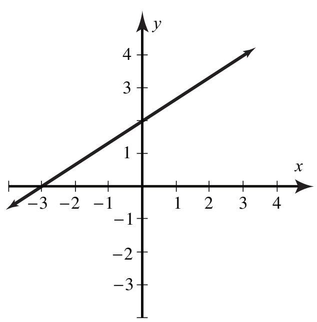


Figure 27

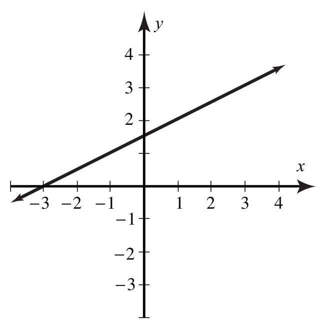


Figure 28

28. For $x = 2y - 3$: $x$-intercept, then $y = 0 \Rightarrow x = 2(0) - 3 \Rightarrow x = -3$;

$y$-intercept, then $x = 0 \Rightarrow 0 = 2y - 3 \Rightarrow 2y = 3 \Rightarrow y = \dfrac{3}{2}$. See Figure 28.

29. $4x - 5 = 1 - 2x \Rightarrow 6x = 6 \Rightarrow x = 1$; 1

30. $\dfrac{2x - 4}{2} = \dfrac{3x}{7} - 1 \Rightarrow 14\left(\dfrac{2x - 4}{2} = \dfrac{3x}{7} - 1\right) \Rightarrow 14x - 28 = 6x - 14 \Rightarrow 8x = 14 \Rightarrow x = \dfrac{14}{8} \Rightarrow$

$x = \dfrac{7}{4}$; $\dfrac{7}{4}$

31. $\dfrac{2}{3}(x - 2) - \dfrac{4}{5}x = \dfrac{4}{15} + x \Rightarrow \dfrac{2}{3}x - \dfrac{4}{3} - \dfrac{4}{5}x = \dfrac{4}{15} + x \Rightarrow 15\left(\dfrac{2}{3}x - \dfrac{4}{3} - \dfrac{4}{5}x = \dfrac{4}{15} + x\right) \Rightarrow$

$10x - 20 - 12x = 4 + 15x \Rightarrow -17x = 24 \Rightarrow x = -\dfrac{24}{17}$; $-\dfrac{24}{17}$

32. $-0.3(1 - x) - 0.1(2x - 3) = 0.4 \Rightarrow -0.3 + 0.3x - 0.2x + 0.3 = 0.4 \Rightarrow 0.1x = 0.4 \Rightarrow x = 4$; 4

33. Graph $Y_1 = X + 1$ and $Y_2 = 2X - 2$. See Figure 33a. The lines intersect at point $(3, 4) \Rightarrow x = 3$. Make a table of $Y_1 = X + 1$ and $Y_2 = 2X - 2$ for $x$ values from 0 to 5. See Figure 33b.

    Both equations have $y$-value 4 at $x = 3$.

[−10, 10, 1] by [−10, 10, 1]

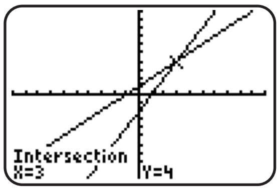



Figure 33a

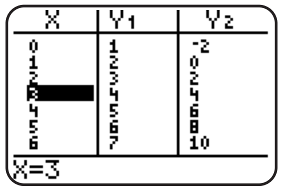



Figure 33b

34. $2x - (5 - x) = \dfrac{1 - 4x}{2} + 5(x - 2) \Rightarrow 3x - 5 = \dfrac{1 - 4x}{2} + 5x - 10 \Rightarrow$

    $6x - 10 = 1 - 4x + 10x - 20 \Rightarrow 6x - 10 = 6x - 19 \Rightarrow -10 = -19$, no solutions $\Rightarrow$ The equation is a contradiction.

35. $(-\infty, 5)$

36. $[-2, 5]$

37. $(-\infty, -2) \cup (2, \infty)$

38. $[-3, \infty)$

39. $-3(1 - 2x) + x \le 4 - (x + 2) \Rightarrow -3 + 6x + x \le 4 - x - 2 \Rightarrow 7x - 3 \le -x + 2 \Rightarrow 8x \le 5 \Rightarrow$

    $x \le \dfrac{5}{8} \Rightarrow \left(-\infty, \dfrac{5}{8}\right]$. In set builder notation the interval is $\left\{x \,|\, x \le \dfrac{5}{8}\right\}$.

40. $\dfrac{1}{3} \le \dfrac{2 - 3x}{2} < \dfrac{4}{3} \Rightarrow 6\left(\dfrac{1}{3} \le \dfrac{2 - 3x}{2} < \dfrac{4}{3}\right) \Rightarrow 2 \le 6 - 9x < 8 \Rightarrow -4 \le -9x < 2 \Rightarrow$

    $\dfrac{4}{9} \ge x > -\dfrac{2}{9} \Rightarrow -\dfrac{2}{9} < x \le \dfrac{4}{9} \Rightarrow \left(-\dfrac{2}{9}, \dfrac{4}{9}\right]$. In set builder notation the interval is $\left\{x \,|\, -\dfrac{2}{9} < x \le \dfrac{4}{9}\right\}$.

41. (a) 2

    (b) The graph of $f(x)$ is above the graph of $g(x)$ to the left of $x = 2 \Rightarrow x < 2$

    (c) The graph of $f(x)$ intersects or is below the graph of $g(x)$ to the right of $x = 2 \Rightarrow f(x) \le g(x)$ when $x \ge 2$.

42. See Figure 42. $f$ has a break in it at $x = 2 \Rightarrow f$ is not continuous.

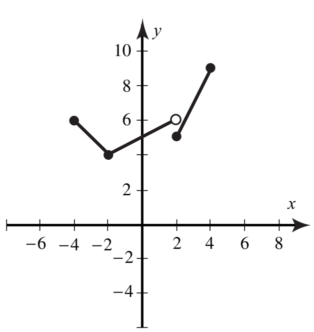



Figure 42

43. $|d + 1| = 5 \Rightarrow d + 1 = 5$ or $d + 1 = -5$. If $d + 1 = -5, d = -6$; if $d + 1 = 5, d = 4 \Rightarrow -6, 4$.

44. $|3 - 2x| = 7 \Rightarrow 3 - 2x = 7$ or $3 - 2x = -7$. If $3 - 2x = -7, -2x = -10 \Rightarrow x = 5$; if $3 - 2x = 7, -2x = 4 \Rightarrow x = -2 \Rightarrow -2, 5$.

45. $|2t| - 4 = 10 \Rightarrow |2t| = 14 \Rightarrow 2t = 14$ or $2t = -14$. If $2t = -14, t = -\frac{14}{2} \Rightarrow t = -7$; if $2t = 14, t = 7 \Rightarrow -7, 7$.

46. $|11 - 2x| = |3x + 1| \Rightarrow 11 - 2x = 3x + 1$ or $11 - 2x = -(3x + 1)$. If $11 - 2x = 3x + 1$, $-5x = -10 \Rightarrow x = 2$; if $11 - 2x = -(3x + 1), x = -12 \Rightarrow -12, 2$.

47. The solutions to $|2t - 5| \le 5$ satisfy $s_1 \le t \le s_2$ where $s_1$ and $s_2$, are the solutions to $|2t - 5| = 5$.
$|2t - 5| = 5$ is equivalent to $2t - 5 = -5 \Rightarrow t = 0$ or $2t - 5 = 5 \Rightarrow t = 5$.
The interval is $[0, 5]$. In set-builder notation the interval is $\{t \mid 0 \le t \le 5\}$.

48. The solutions to $|5 - 5t| > 7$ satisfy $t < s_1$ or $t > s_2$, where $s_1$ and $s_2$ are the solutions to $|5 - 5t| = 7$.
$|5 - 5t| = 7$ is equivalent to $5 - 5t = -7 \Rightarrow t = \frac{12}{5}$ or $5 - 5t = 7 \Rightarrow t = -\frac{2}{5}$.
The interval is $\left(-\infty, -\frac{2}{5}\right) \cup \left(\frac{12}{5}, \infty\right)$. In set-builder notation the interval is $\left\{t \mid t < -\frac{2}{5} \text{ or } t > \frac{12}{5}\right\}$.

49. $V = \pi r^2 h \Rightarrow 24 = \pi(1.5)^2 h \Rightarrow 24 = \pi(2.25)h \Rightarrow h \approx 3.40$ inches

50. Slope $= \frac{\text{rise}}{\text{run}} = \frac{20}{4} = 5, m_1 = 5$; gravel is being loaded into the truck at a rate of 5 tons per minute.
$m_2 = \frac{0}{16} = 0$: no gravel is being loaded into or unloaded from the truck. $m_3 = -\frac{20}{2} = -10$: gravel is being unloaded from the truck at a rate of 10 tons per minute.

51. (a) $C(1500) = 500(1500) + 20{,}000 = 770{,}000$; it costs \$770,000 to manufacture 1500 computers.
(b) 500; each additional computer costs \$500 to manufacture.

52. If car $B$ is at the origin on a coordinate plane then car $A$ travels $60\left(\frac{5}{4}\right) = 75$ miles and ends up at the point (0, 35), 35 miles north of where car $B$ started. Car $B$ travels $70\left(\frac{5}{4}\right) = 87.5$ miles west and ends up at $(-87.5, 0)$. Using the distance formula:
$d = \sqrt{(-87.5 - 0)^2 + (0 - 35)^2} \Rightarrow d = \sqrt{7656.25 + 1225} \Rightarrow d = \sqrt{8881.25} \Rightarrow d \approx 94.2$ mi.

53. (a) $T(2) = 70 + \frac{3}{2}(2)^2 = 70 + 6 = 76$; $T(4) = 70 + \frac{3}{2}(4)^2 = 70 + 24 = 94$
Using (2, 76) and (4, 94): $m = \frac{94 - 76}{4 - 2} = \frac{18}{2} = 9$°F increase per hour.
(b) On average the temperature increased by 9°F per hour over this 2-hour period.

54. (a) $D(x) = 270 - 72x$

(b) Since $72x = 270 \Rightarrow x = 3.75$, the driver arrives home in 3.75 hours, so times after that are unnecessary. An appropriate domain is $\{x \mid 0 \le x \le 3.75\}$. See figure 54.

(c) $x$-intercept: when $y = 0 \Rightarrow 0 = 270 - 72(x) \Rightarrow 72x = 270 \Rightarrow x = 3.75$; the driver arrives home after 3.75 hours. $y$-intercept: when $x = 0 \Rightarrow y = 270 - 72(0) \Rightarrow y = 270$; the driver is initially 270 miles from home.

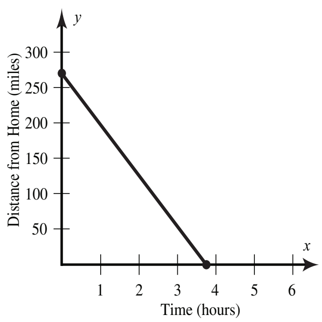


Figure 54

55. Let $t =$ time for the two to mow the lawn together. Then the first person mows $\frac{1}{5}t$ of the lawn and the second person mows $\frac{1}{12}t$ of the lawn $\Rightarrow \frac{1}{5}t + \frac{1}{12}t = 1 \Rightarrow \frac{12}{60}t + \frac{5}{60}t = 1 \Rightarrow \frac{17}{60}t = 1 \Rightarrow t = \frac{60}{17} = 3.53$ hours.

56. Let $x =$ time run at 8 mph and $\left(\frac{7}{4} - x\right) =$ time run at 10 mph. Then $8x + 10\left(\frac{7}{4} - x\right) = 15 \Rightarrow$ $8x + \frac{70}{4} - 10x = 15 \Rightarrow -2x = -\frac{10}{4} \Rightarrow x = \frac{5}{4} \Rightarrow$ 1.25 hours at 8mph and then 0.5 hour at 10 mph.

57. (a) Using (2001, 56) and (2012, 61), $m = \frac{61 - 56}{2012 - 2001} = \frac{5}{11}$; $f(x) = \frac{5}{11}(x - 2001) + 56$

(b) $f(2007) = \frac{5}{11}(2007 - 2001) + 56 = \frac{5}{11}(6) + 56 = \frac{30}{11} + 56 \approx 58.7$ lbs.

58. $\left|\frac{M - A}{A}\right| \le 0.03 \Rightarrow \left|\frac{M - 65}{65}\right| \le 0.03 \Rightarrow -0.03 \le \frac{M - 65}{65} \le 0.03 \Rightarrow -1.95 \le M - 65 \le 1.95 \Rightarrow$ $63.05 \le M \le 66.95 \Rightarrow$ 63.05 to 66.95

59. (a) Enter the data (1970, 4095), (1980, 10,182), (1990, 19,572) and (2000, 29,760);

$f(x) = 863.84x - 1{,}698{,}819.9$

(b) $f(1995) \approx 863.84(1995) - 1{,}698{,}819.9 \approx \$24{,}541$; this estimate is an interpolation.

60. (a) The slope of the line passing through (58, 91) and (64, 111) is $m = \frac{111 - 91}{64 - 58} = \frac{10}{3}$. Thus, let $f(x) = \frac{10}{3}(x - 58) + 91$.

(b) $f(61) = \frac{10}{3}(61 - 58) + 91 = 101$. The recommended minimum weight is 101 pounds for a person 61 inches tall. Since 61 inches is the midpoint between 58 and 64 inches, we can use a midpoint approximation. The midpoint between (58, 91) and (64, 111) is $\left(\frac{58 + 64}{2}, \frac{91 + 111}{2}\right) = (61, 101)$. The recommended minimum weight is again 101. The midpoint formula gives the midpoint on the graph of $f$ between the two given points. The answers are the same.