CHAPTER 1
Functions Graphs, and Models; Linear Functions

Algebra Toolbox Exercises

1. $\{1,2,3,4,5,6,7,8\}$ and
$\{x \mid x < 9, x \in \mathbb{N}\}$
Remember that $x \in \mathbb{N}$ means that x is a natural number.

2. Yes.

3. Yes. Every element of B is also in A.

4. No. $\mathbb{N} = \{1,2,3,4,...\}$. Therefore, $\frac{1}{2} \notin \mathbb{N}$.

5. Yes. Every integer can be written as a fraction with the denominator equal to 1.

6. Yes. Irrational numbers are by definition numbers that are not rational.

7. Integers. Note this set of integers could also be considered a set of rational numbers. See question 5.

8. Rational numbers

9. Irrational numbers

10. $x > -3$

11. $-3 \le x \le 3$

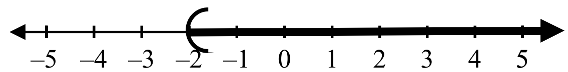
12. $x \le 3$

13. $(-\infty, 7]$

14. $(3, 7]$

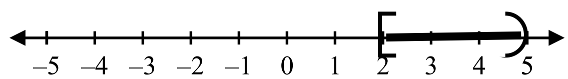
15. $(-\infty, 4)$

16.



17.

Note that $5 > x \ge 2$ implies $2 \le x < 5$, therefore



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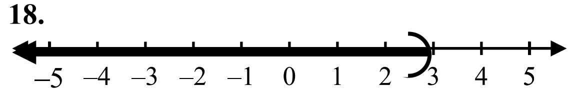

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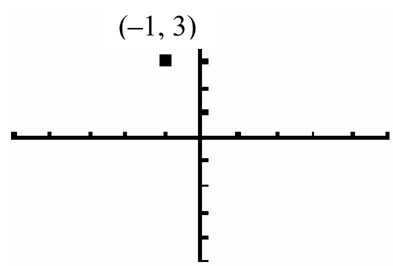

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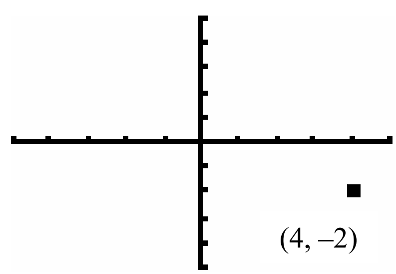

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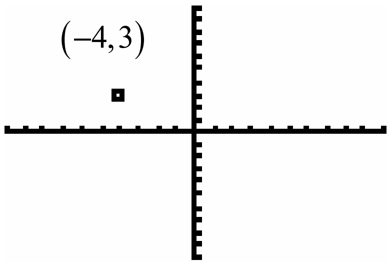


22. $|-6| = 6$

23. $|7-11| = |-4| = 4$

24. The x^2 term has a coefficient of –3. The x term has a coefficient of –4. The constant term is 8.

25. The x^4 term has a coefficient of 5. The x^3 term has a coefficient of 7. The constant term is –3.

26. $\left(z^4 - 15z^2 + 20z - 6\right) + \left(2z^4 + 4z^3 - 12z^2 - 5\right)$

$= \left(z^4 + 2z^4\right) + \left(4z^3\right) + \left(-15z^2 - 12z^2\right) +$

$\left(20z\right) + \left(-6 - 5\right)$

$= 3z^4 + 4z^3 - 27z^2 + 20z - 11$

27. $-2x^3y^4 + \left(2y^4 + 5y^4\right) - 3y^2 +$

$\left(3x - 5x\right) + \left(-119 + 110\right)$

$= -2x^3y^4 + 7y^4 - 3y^2 - 2x - 9$

28. $4\left(p + d\right)$

$= 4p + 4d$

29. $-2\left(3x - 7y\right)$

$= \left(-2 \bullet 3x\right) + \left(-2 \bullet -7y\right)$

$= -6x + 14y$

30. $-a\left(b + 8c\right)$

$= -ab - 8ac$

31. $4\left(x - y\right) - \left(3x + 2y\right)$

$= 4x - 4y - 3x - 2y$

$= 1x - 6y$

$= x - 6y$

32. $4\left(2x - y\right) + 4xy - 5\left(y - xy\right) - \left(2x - 4y\right)$

$= 8x - 4y + 4xy - 5y + 5xy - 2x + 4y$

$= \left(8x - 2x\right) + \left(-4y - 5y + 4y\right) + \left(4xy + 5xy\right)$

$= 6x - 5y + 9xy$

33. $2x\left(4yz - 4\right) - \left(5xyz - 3x\right)$

$= 8xyz - 8x - 5xyz + 3x$

$= \left(8xyz - 5xyz\right) + \left(-8x + 3x\right)$

$= 3xyz - 5x$

34. $\frac{3x}{3} = \frac{6}{3}$

$x = 2$

35. $\frac{x}{3} = 6$

$\left(\frac{3}{1}\right)\left(\frac{x}{3}\right) = \left(\frac{3}{1}\right)\left(\frac{6}{1}\right)$

$x = \frac{18}{1}$

$x = 18$

36. $x + 3 = 6$

$x + 3 - 3 = 6 - 3$

$x = 3$

37. $4x-3=6+x$

$4x-x-3=6+x-x$

$3x-3=6$

$3x-3+3=6+3$

$3x=9$

$\frac{3x}{3}=\frac{9}{3}$

$x=3$

38. $3x-2=4-7x$

$3x+7x-2=4-7x+7x$

$10x-2=4$

$10x-2+2=4+2$

$10x=6$

$\frac{10x}{10}=\frac{6}{10}$

$x=\frac{6}{10}$

$x=\frac{3}{5}$

39. $\frac{3x}{4}=12$

$4\left(\frac{3x}{4}\right)=4(12)$

$3x=48$

$x=16$

40. $2x-8=12+4x$

$2x-4x-8=12+4x-4x$

$-2x-8+8=12+8$

$-2x=20$

$\frac{-2x}{-2}=\frac{20}{-2}$

$x=-10$

Section 1.1 Skills Check

1. Using Table A

a. –5 is an x-value and therefore is an input into the function $f(x)$.

b. $f(-5)$ represents an output from the function.

c. The domain is the set of all inputs. D: $\{-9,-7,-5,6,12,17,20\}$. The range is the set of all outputs. R: $\{4,5,6,7,9,10\}$

d. Every input x into the function f yields exactly one output $y = f(x)$.

2. Using Table B

a. 3 is an x-value and therefore is an input into the function $f(x)$.

b. $g(7)$ represents an output from the function

c. The domain is the set of all inputs. D: $\{-4,-1,0,1,3,7,12\}$. The range is the set of all outputs. R: $\{3,5,7,8,9,10,15\}$

d. Every input x into the function f yields exactly one output $y = g(x)$.

3. $f(-9) = 5$
$f(17) = 9$

4. $g(-4) = 5$
$g(3) = 8$

5. No. In the given table, x is not a function of y. If y is considered the input variable, one input will correspond with more than one output. Specifically, if $y = 9$, then $x = 12$ or $x = 17$.

6. Yes. Each input y produces exactly one output x.

7. a. $f(2) = -1$

b. $$\begin{aligned} f(2) &= 10 - 3(2)^2 \\ &= 10 - 3(4) \\ &= 10 - 12 \\ &= -2 \end{aligned}$$

c. $f(2) = -3$

8. a. $f(-1) = 5$

b. $f(-1) = -8$

c. $$\begin{aligned} f(-1) &= (-1)^2 + 3(-1) + 8 \\ &= 1 - 3 + 8 \\ &= 6 \end{aligned}$$

9. Recall that $R(x) = 5x + 8$.

a. $R(-3) = 5(-3) + 8 = -15 + 8 = -7$

b. $R(-1) = 5(-1) + 8 = -5 + 8 = 3$

c. $R(2) = 5(2) + 8 = 10 + 8 = 18$

10. Recall that $C(s) = 16 - 2s^2$.

a. $$\begin{aligned} C(3) &= 16 - 2(3)^2 \\ &= 16 - 2(9) \\ &= 16 - 18 \\ &= -2 \end{aligned}$$

b. $C(-2) = 16 - 2(-2)^2$
$= 16 - 2(4)$
$= 16 - 8$
$= 8$

c. $C(-1) = 16 - 2(-1)^2$
$= 16 - 2(1)$
$= 16 - 2$
$= 14$

11. Yes. Every input corresponds with exactly one output. The domain is $\{-1, 0, 1, 2, 3\}$. The range is $\{-8, -1, 2, 5, 7\}$.

12. No. Every input *x* does not match with exactly one output *y*. Specifically, if $x = 2$ then $y = -3$ or $y = 4$.

13. No. The graph fails the vertical line test. Every input does not match with exactly one output.

14. Yes. The graph passes the vertical line test. Every input matches with exactly one output.

15. No. If $x = 3$, then $y = 5$ or $y = 7$. One input yields two outputs. The relation is not a function.

16. Yes. Every input *x* yields exactly one output *y*.

17. a. Not a function. If $x = 4$, then $y = 12$ or $y = 8$.

b. Yes. Every input yields exactly one output.

18. a. Yes. Every input yields exactly one output.

b. Not a function. If $x = 3$, then $y = 4$ or $y = 6$.

19. a. Not a function. If $x = 2$, then $y = 3$ or $y = 4$.

b. Function. Every input yields exactly one output.

20. a. Function. Every input yields exactly one output.

b. Not a function. If $x = -3$, then $y = 3$ or $y = -5$.

21. No. If $x = 0$, then $(0)^2 + y^2 = 4 \Rightarrow y^2 = 4 \Rightarrow y = \pm 2$. So, one input of 0 corresponds with 2 outputs of –2 and 2. Therefore the equation is not a function.

22. Yes. Every input for *x* corresponds with exactly one output for *y*.

23. $C = 2\pi r$, where *C* is the circumference and *r* is the radius.

24. *D* is found by squaring *E*, multiplying the result by 3, and subtracting 5.

25. A function is a correspondence that assigns to each element of the domain exactly one element of the range.

26. The domain of a function is the set of all possible inputs into the function.

27. The range of a function is the set of all possible outputs from the function.

28. The vertical-line test says that if no vertical line intersects the graph of an equation in more than one point, then the equation is a function.

Section 1.1 Exercises

29. a. No. Every input (x, given day) would correspond with multiple outputs (p, stock prices). Stock prices fluctuate throughout the trading day.

b. Yes. Every input (x, given day) would correspond with exactly one output (p, the stock price at the end of the trading day).

30. a. Yes. Every input (stepping on the scale) corresponds with exactly one output (the man's weight).

b. No. Every input corresponds with multiple outputs. The man's weight will fluctuate throughout the given year, x.

31. Yes. Every input (month) corresponds with exactly one output (cents per pound).

32. a. Yes. Every input (age in years) corresponds with exactly one output (life insurance premium).

b. No. One input of $11.81 corresponds with six outputs.

33. Yes. Every input (education level) corresponds with exactly one output (average income).

34. Yes. The graph of the equation passes the vertical line test.

35. Yes. Yes. Every input (depth) corresponds with exactly one output (pressure). The graph of the equation passes the vertical line test.

36. Yes. The graph of the equation passes the vertical line test.

37. a. Yes. Every input (day of the month) corresponds with exactly one output (weight).

b. The domain is $\{1,2,3,4,\ldots,13,14\}$.

c. The range is $\{171,172,173,174,175,176,177,178\}$.

d. The highest weights were on May 1 and May 3.

e. The lowest weight was May 14.

f. Three days from May 12 until May 14.

38. a. No. One input of 75 matches with two outputs of 70 and 81.

b. Yes. Every input (average score on the final exam) matches with exactly one output (average score on the math placement test).

39. a. $B(3)=16{,}115$

b. $B(2)=23{,}047$. $B(2)$ represents the balance owed by the couple at the end of two years.

c. Year 2.

d. $t=4$

40. a. The couple must make payments for 20 years.
$20=f(103{,}000)$

b. $f(89{,}000)=15$. It will take the couple 15 years to payoff an $89,000 mortgage at 7.5%.

c. $f(120{,}000)=30$

d. $f(3 \cdot 40{,}000)=f(120{,}000)=30$
$3 \cdot f(40{,}000)=3 \cdot 5=15$
The expressions are not equal.

41. a. When $t=2005$, the ratio is approximately 4.

b. $f(2005)=4$. For year 2005 the projected ratio of working-age population to the elderly is 4.

c. The domain is the set of all possible inputs. In this example, the domain consists of all the years, *t*, represented in the figure. Specifically, the domain is $\{1995, 2000, 2005, 2010, 2015, 2020, 2025, 2030\}$.

d. As the years, *t*, increase, the projected ratio of the working-age population to the elderly decreases. Notice that the bars in the figure grow smaller as the time increases.

42. a. Approximately 22 million

b. $f(1890)=4$. Approximately 4 million women were in the work force in 1890.

c. $\{1890,1900,1920,1930,1940,1950,1960,1970,1980,1990\}$

d. Increasing. Note that as the year increases, the number of women in the work force also increases.

43. a. $f(1990)=492{,}671$

b. The domain is the set of all possible inputs. In this example, the domain is all the years, *t*, represented in the table. Specifically, the domain is $\{1985,1986,1987,\ldots,1997,1998\}$.

c. The maximum number of firearms is 581,697, occurring in year 1993. Note that $f(1993) = 581,687$.

44. a. The domain is $\{0,5,10,15,18\}$.

b. The range is $\{1.02,1.06,1.10,1.26,1.48\}$.

c. When the input is 10, the output is 1.10. In 1990, 1.10 billion people in the U.S. were admitted to movies.

d. As the years past 1980 increase, the movie admissions also increase. The table represents an increasing function.

45. a. Yes. Every year, *t*, corresponds with exactly one percentage, *p*.

b. $f(1840) = 68.6$. $f(1840)$ represents the percentage of U.S. workers in a farm occupation in the year 1840.

c. If $f(t) = 27$, then $t = 1920$.

d. $f(1960) = 6.1$ implies that in 1960, 6.1% of U.S. workers were employed in a farm occupation.

e. As the time, *t*, increases, the percentage, *p*, of U.S. workers in farm occupations decreases. Note that the graph is sloping down if it is read from left to right.

46. a. In 1995, 9.4 million homes used the Internet.

b. $f(1997) = 21.8$. In 1997, 21.8 million U.S. homes used the Internet.

c. 1998

d. The function is increasing very rapidly. Beyond 1998, the function continues to increase rapidly because of the fast growth in Internet usage in the U.S.

47. a. $f(1990) = 3.4$. In 1990 there are 3.4 workers for each retiree.

b. 2030

c. As the years increase, the number of workers available to support retirees decreases. Therefore, funding for social security into the future is problematic. Workers will need to pay larger portion of their salaries to fund payments to retirees.

48. a. When the input is 1995 the output is approximately 103. This implies that the pregnancy rate per 1000 girls in 1995 was approximately 103.

b. The rate was 113 in 1989 and 1992.

c. The rate increased from 1984-85 and again from 1987-1991.

d. 1991. In 1991, the pregnancy rate per 1000 girls is approximately 117.

49. a. $R(200) = 32(200) = 6400$. The revenue generated from selling 200 golf hats is \$6400.

b. $R(2500) = 32(2500) = \$80,000$

50. a. $C(200) = 4000 + 12(200) = 6400$. The production cost of manufacturing 200 golf hats is \$6400.

b. $C(2500) = 4000 + 12(2500)$
$= \$34,000$

51. a. $P(500) = 450(500) - 0.1(500)^2 - 2000$
$= 225{,}000 - 25{,}000 - 2000$
$= 198{,}000$
The profit generated from selling 500 ipod players is \$198,000.

b. $P(4000)$
$= 450(4000) - 0.1(4000)^2 - 2000$
$= 1{,}800{,}000 - 1{,}600{,}000 - 2000$
$= \$198{,}000$

52. a. $P(200) = 20(200) - 4000$
$= 4000 - 4000$
$= 0$
The profit generated from selling 200 golf hats is \$0.

b. $P(2500) = 20(2500) - 4000$
$= 50{,}000 - 4000$
$= \$46{,}000$

53. a. $f(1000) = 0.105(1000) + 5.80$
$= 105 + 5.80$
$= 110.80$
The monthly charge for using 1000 kilowatt hours is \$110.80.

b. $f(1500) = 0.105(1500) + 5.80$
$= 157.5 + 5.80$
$= \$163.30$

54. a. $P(100) = 32(100) - 0.1(100)^2 - 1000$
$= 3200 - 1000 - 1000$
$= 1200$
The daily profit for producing 100 Blue Chief bicycles is \$2100.

b. $P(160) = 32(160) - 0.1(160)^2 - 1000$
$= 5120 - 2560 - 1000$
$= \$1560$

55. a. $h(1) = 6 + 96(1) - 16(1)^2$
$= 6 + 96 - 16$
$= 86$
The height of the ball after one second is 86 feet.

b. $h(3) = 6 + 96(3) - 16(3)^2$
$= 6 + 288 - 144$
$= 150$
After three seconds the ball is 150 feet high.

c. Test $t = 5$.
$h(5) = 6 + 96(5) - 16(5)^2$
$= 6 + 480 - 400$
$= 86$
After five seconds the ball is 86 feet high. The ball does eventually fall, since the height at $t = 5$ is lower than the height at $t = 3$. Considering the following table of values for the function, it seems reasonable to estimate that the ball stops climbing at $t = 3$.

X	Y1	
0	6	
1	86	
2	134	
3	150	
4	134	
5	86	
6	6	

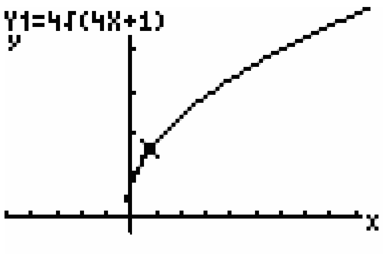
X=0

56. a. $f(1995) = 62.6$
$f(1999) = 66.1$

b. $g(1995) = 48.0$. In 1995 48.0% of Hispanic males have completed at least some college.

c. $h(1983) = 42.0$
$h(1999) = 52.1$

d. $f(1987) = 51.5$. In 1987 51.5% of white males had completed some college.

57. 

a. Yes. The graph seems to pass the vertical line test.

b. Any input into the function must not create a negative number under the radical. Therefore, the radicand, $4s+1$, must be greater than or equal to zero.

$$4s+1 \geq 0$$
$$4s+1-1 \geq 0-1$$
$$4s \geq -1$$
$$s \geq -\frac{1}{4}$$

Therefore, based on the equation, the domain is $\left[-\frac{1}{4}, \infty\right)$.

c. Since s represents wind speed in the given function and wind speed cannot be less than zero, the domain of the function is restricted based on the physical context of the problem. Even though the domain implied by the function is $\left[-\frac{1}{4}, \infty\right)$, the actual domain in the given physical context is $[0, \infty)$.

58. a. $0.3 + 0.7n = 0$

$$0.7n = -0.3$$
$$\frac{0.7n}{0.7} = \frac{-0.3}{0.7}$$
$$n = -\frac{3}{7}$$

Therefore the domain of $R(n)$ is all real numbers except $-\frac{3}{7}$ or $\left(-\infty, -\frac{3}{7}\right) \cup \left(-\frac{3}{7}, \infty\right)$.

b. In the context of the problem, n represents the factor for increasing the number of questions on a test. Therefore it makes sense that $n \geq 0$.

59. a. The domain is $[0, 100)$.

b. $C(60) = \dfrac{237{,}000(60)}{100-60} = 355{,}500$

$C(90) = \dfrac{237{,}000(90)}{100-90} = 2{,}133{,}000$

60. a. Considering the square root

$$2p+1 \geq 0$$
$$2p \geq -1$$
$$p \geq -\frac{1}{2}$$

Since the denominator can not equal zero, $p \neq -\frac{1}{2}$.

Therefore the domain of q is $\left(-\frac{1}{2}, \infty\right)$.

b. In the context of the problem, p represents the price of a product. Since the price can not be negative, $p \geq 0$. The domain is $[0, \infty)$. Also, since q represents the quantity of the product demanded by consumers, $q \geq 0$. The range is $[0, \infty)$.

61. a. $V(12) = (12)^2(108-4(12))$
$= 144(108-48)$
$= 144(60)$
$= 8640$
$V(18) = (18)^2(108-4(18))$
$= 324(108-72)$
$= 324(36)$
$= 11{,}664$

b. First, since x represents a side length in the diagram, then x must be greater than zero. Second, to satisfy postal restrictions, the length plus the girth must be less than or equal to 108 inches. Therefore,

$$\text{Length} + \text{Girth} \leq 108$$
$$\text{Length} + 4x \leq 108$$
$$4x \leq 108 - \text{Length}$$
$$x \leq \frac{108 - \text{Length}}{4}$$
$$x \leq 27 - \frac{\text{Length}}{4}$$

Since x is greatest if the length is smallest, let the length equal zero to find the largest value for x.

$$x \leq 27 - \frac{0}{4}$$
$$x \leq 27$$

Therefore the conditions on x and the corresponding domain for the function $V(x)$ are $0 \leq x \leq 27$ or $x \in [0, 27]$.

c.

X	Y1
10	6800
12	8640
14	10192
16	11264
18	11664
20	11200
22	9680

X=18

The maximum volume occurs when $x = 18$. Therefore the dimensions that maximize the volume of the box are 18 inches by 18 inches by 36 inches.

62. a. $S(0) = -4.9(0)^2 + 98(0) + 2 = 2$
The initial height of the bullet is 2 meters.

b.

X	Y1
6	413.6
7	447.9
8	472.4
9	487.1
10	492
11	487.1
12	472.4

Y1=487.1

$S(9) = 487.1$
$S(10) = 492$
$S(11) = 487.1$

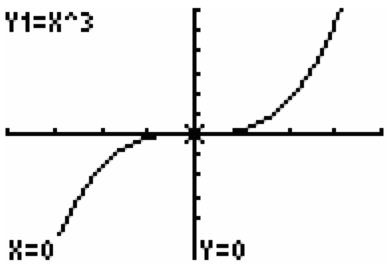
c. The bullet seems to reach a maximum height at 10 seconds and then begins to fall. See the table in part b) for further verification.

Section 1.2 Skills Check

1. a.

x	$y = x^3$	(x, y)
–3	–27	(–3, 27)
–2	–8	(–2, –8)
–1	–1	(–1, –1)
0	0	(0, 0)
1	1	(1, 1)
2	8	(2, 8)
3	27	(3, 27)

b.



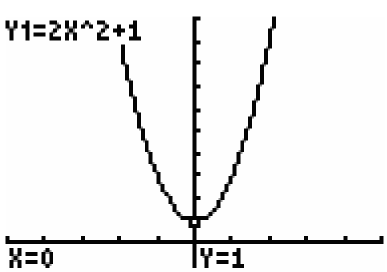
[–4,4] by [–30,30]

c. The graphs are the same.

2. a.

x	$y = 2x^2 + 1$	(x, y)
–3	19	(–3, 19)
–2	9	(–2, 9)
–1	3	(–1, 3)
0	1	(0, 1)
1	3	(1, 3)
2	9	(2, 9)
3	19	(3, 19)

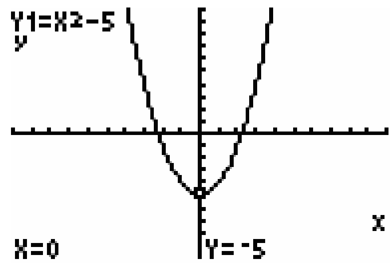
b.



[–5, 5] by [–1, 10]

c. The graphs are the same, although the scale for part b) is smaller than the scale required for part a).

3.



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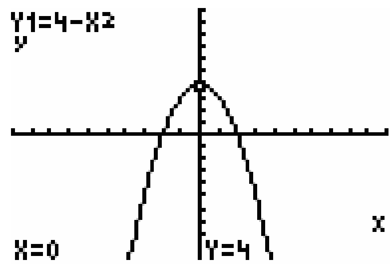

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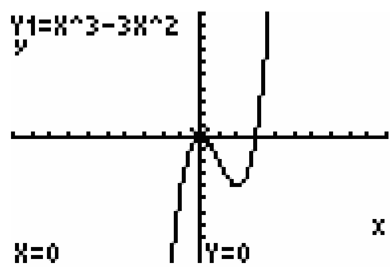

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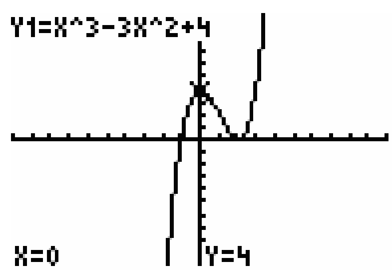

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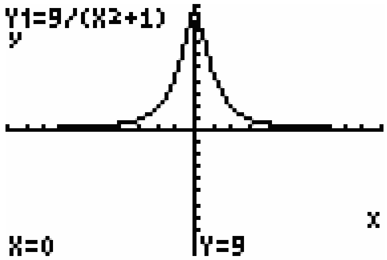
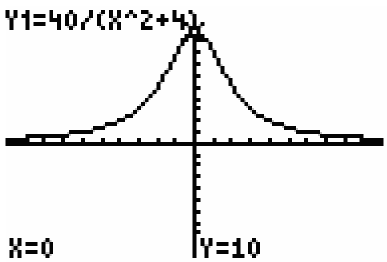
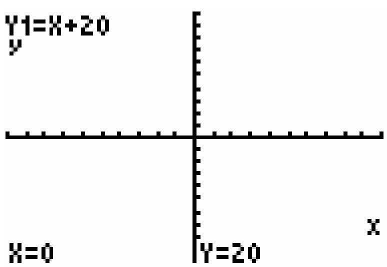


8.

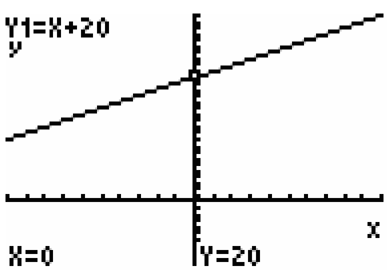


9. a.



[–10, 10] by [–10, 10]

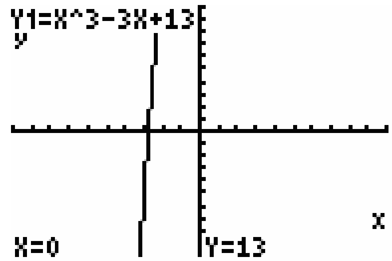
b.



[10, 10] by [–10, 30]

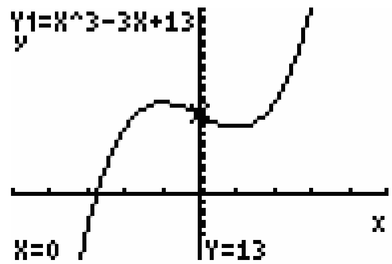
View b) is better.

10. a.



[–10, 10] by [–10, 10]

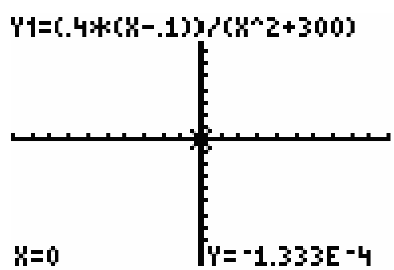
b.



[–5, 5] by [–10, 30]

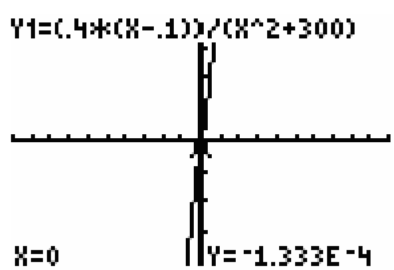
View b) is better.

11. a.



[–10, 10] by [–10, 10]

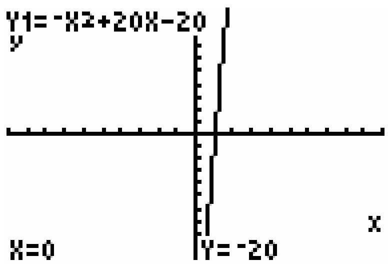
b.



[–20, 20] by [–0.02, 0.02]

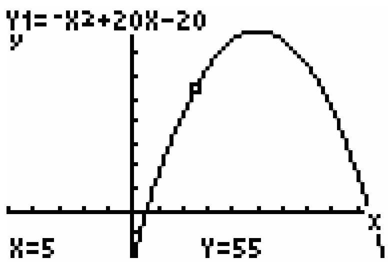
View b) is better.

12. a.



[–10, 10] by [–10, 10]

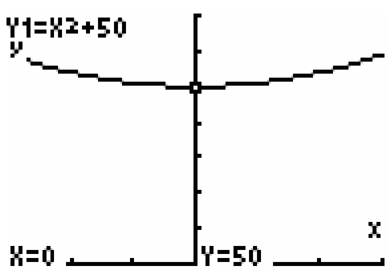
b.



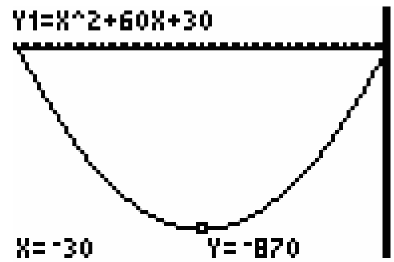
[–10, 20] by [–20, 90]

View b) is better.

13. When $x = -3$ or $x = 3$, $y = 59$. When $x = 0$, $y = 50$. Therefore, $[-3,3]$ by $[0,70]$ is an appropriate viewing window. {Note that answers may vary.}

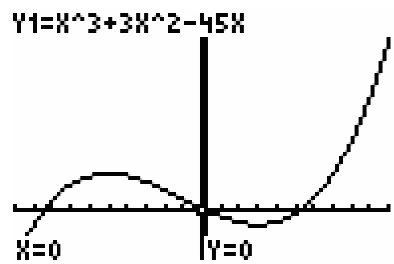


14. When $x = -60, y = 30$. When $x = 0, y = 30$. When $x = -30, y = -870$. Therefore, $[-60,0]$ by $[-1000,200]$ is an appropriate viewing window. {Note that answers may vary.}



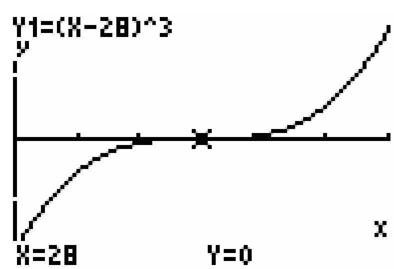
[–60, 0] by [–1000, 200]

15. When $x = -10, y = 250$. When $x = 10, y = 850$. When $x = 0, y = 0$. Therefore, $[-10,10]$ by $[-250,1000]$ is an appropriate viewing window. {Note that answers may vary.}



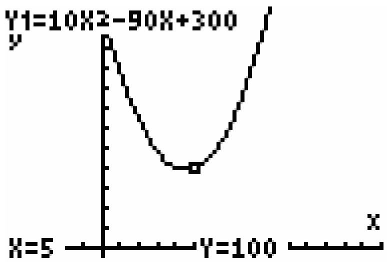
$[-10,10]$ by $[-250,1000]$

16. When $x = 28$, $y = 0$. When $x = 28$, $y = -27$. When $x = 31$, $y = 27$. Therefore, $[25,31]$ by $[-30,30]$ is an appropriate viewing window. {Note that answers may vary.}



$[25,31]$ by $[-30,30]$

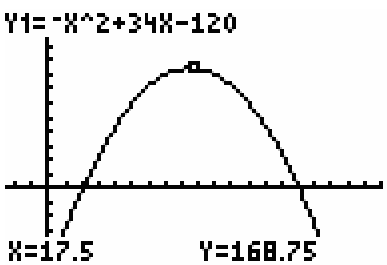
17.



[–5, 15] by [–10, 300]

{Note that answers may vary.}

18.



[–5, 40] by [–100, 250]
{Note that answers may vary.}

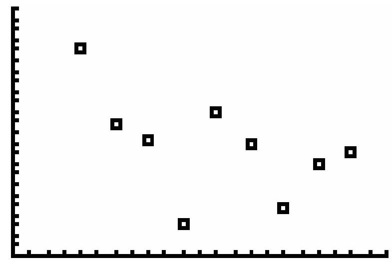
19.

t	$S(t)=5.2t-10.5$
12	51.9
16	72.7
28	135.1
43	213.1

20.

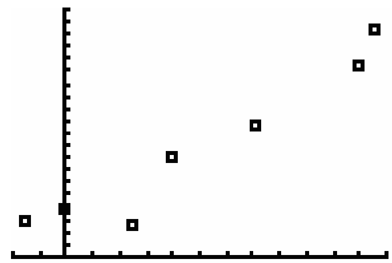
q	$f(q)=3q2-5q+8$
–8	240
–5	108
24	1616
43	5340

21.



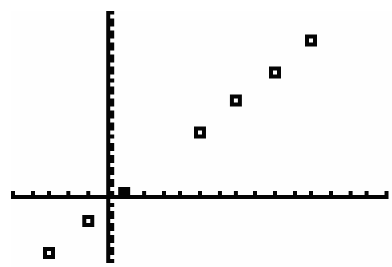
[0, 110] by [0, 600]

22.



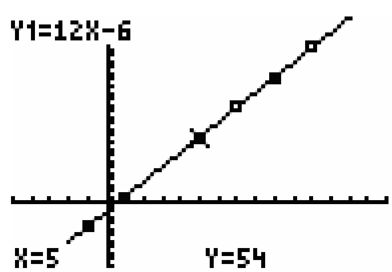
[–20, 120] by [0, 80]

23. a.



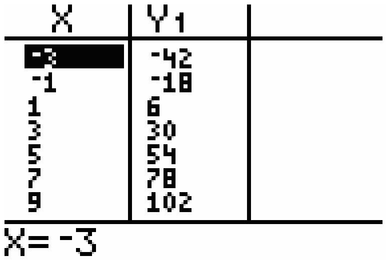
[–5, 15] by [–50, 150]

b.



[–5, 15] by [–50, 150]

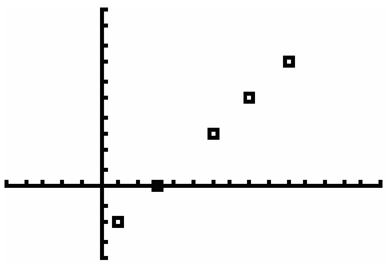
c. Yes. Yes. Compare the following table of points generated by $f(x)=12x-6$ to the given table of points:



X	Y1
-3	-42
-1	-18
1	6
3	30
5	54
7	78
9	102

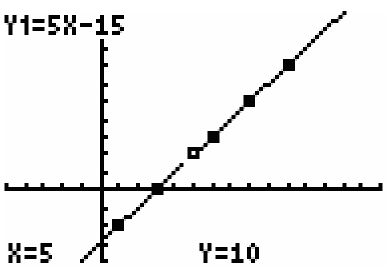
X= -3

24. a.



[–5, 15] by [–20, 50]

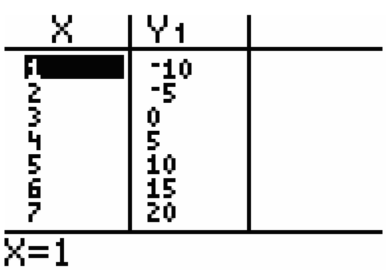
b.



[–5, 15] by [–20, 50]

c. Yes. Yes. Compare the following table of points generated by $f(x) = 5x - 15$ to the given table of points:

d.



X	Y1
1	-10
2	-5
3	0
4	5
5	10
6	15
7	20

X=1

25. a.

$$f(20) = (20)^2 - 5(20) = 400 - 100 = 300$$

b. $x = 20$ implies 20 years after 2000. Therefore the answer to part a) yields the millions of dollars earned in 2020.

26. a.

$$f(10) = 100(10)^2 - 5(10) = 10{,}000 - 50 = 9950$$

b. In 2010, $x = 10$. Therefore, 9950 thousands of units or 9,950,000 units are produced in 2010.

Section 1.2 Exercises

27. a. $x = \text{Year} - 1990$

For 1994, $x = 1994 - 1990 = 4$

For 1998, $x = 1998 - 1990 = 8$

b. $y = -112(8)^2 - 107(8) + 15056 = 7032$

7032 represents the number of welfare cases in Niagara, Canada in 1998.

c. For 1995, $x = 5$. Therefore,

$$y = -112(5)^2 - 107(5) + 15{,}056$$
$$= 11{,}721$$

There were 11,721 welfare cases in Niagara, Canada in 1995.

28. a. $y = 7(44)^2 - 19.88(44) + 409.29$

$$= 13{,}552 - 874.72 + 409.29$$
$$= 13{,}086.57$$

In 1944 there were 13,086.57 thousand women in the workforce.

b. In 1980, $x = 80$.

$$y = 7(80)^2 - 19.88(80) + 409.29$$
$$= 44{,}800 - 1590.4 + 409.29$$
$$= 43{,}618.89$$

In 1980 there were 43,618.89 thousand women in the workforce.

29. a. $t = \text{Year} - 1995$

For 1996, $t = 1996 - 1995 = 1$

For 2004, $t = 2004 - 1995 = 9$

b. $P = f(8) = 6.02(8) + 3.53 = 51.69$.

51.96 represents the percentage of households with Internet access in 2003.

c. $x_{\text{min}} = 1995 - 1995 = 0$

$x_{\text{max}} = 2005 - 1995 = 10$

30. a. $t = \text{Year} - 1980$

For 1982, $t = 1982 - 1980 = 2$

For 1988, $t = 1988 - 1980 = 8$

For 2000, $t = 2000 - 1980 = 20$

b. $P = f(4)$

$$= 35(4)^2 + 740(4) + 1207$$
$$= 4727$$

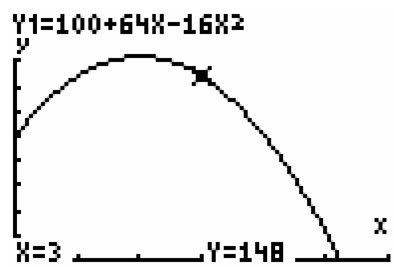
4727 represents the cost of prizes and expenses in millions of dollars for state lotteries in 1984.

c. $x_{\text{min}} = 1980 - 1980 = 0$

$x_{\text{max}} = 1997 - 1980 = 17$

31. $S = 100 + 64t - 16t^2$

a.



[0, 6] by [0, 200]

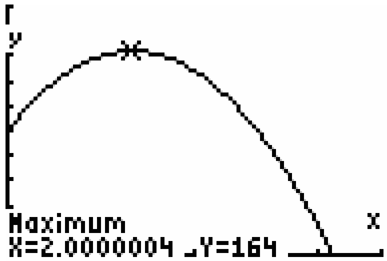
b.

X	Y1
0	100
1	148
2	164
3	148
4	100
5	20
6	-92

X=0

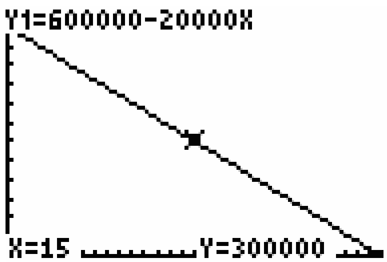
Considering the table, $S = 148$ feet when x is 1 or when x is 3. The height is the same for two different times because the height of the ball increases, reaches a maximum height, and then decreases.

c. The maximum height is 164 feet, occurring 2 seconds into the flight of the ball.



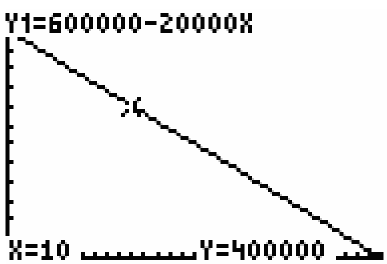
32. $V = 600{,}000 - 20{,}000x$

a.



[0, 30] by [0, 600,000]

b.

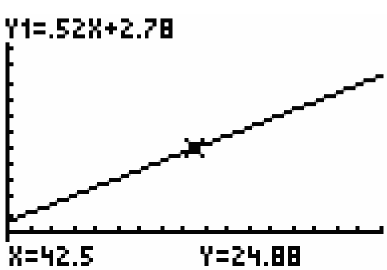


[0, 30] by [0, 600,000]

When $x = 10, y = 40{,}000$.

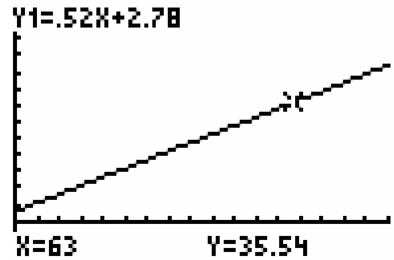
33. $F = 0.52M + 2.78$

a.



[0, 85] by [0, 65]

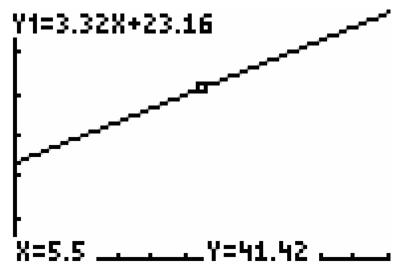
b.



When $x = 63$, $y = 35.54$. Therefore, when the median male salary is $63,000, the median female salary is $35,540.

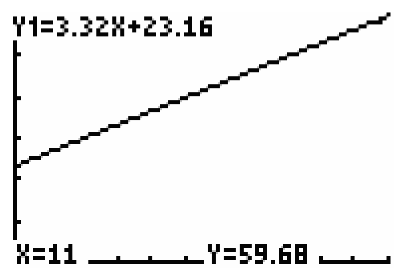
34. $S = 3.32x + 23.16$

a.



[0, 11] by [0, 60]

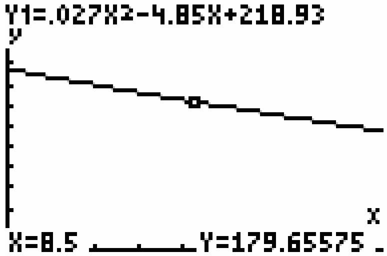
b.



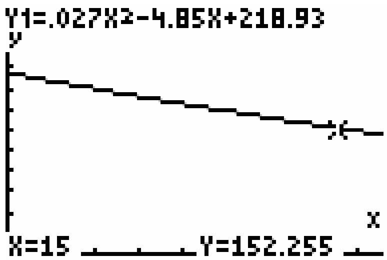
[0, 11] by [0, 60]

In 2001, federal spending on education is approximately $59.68 billion.

35. $S = 0.027t^2 - 4.85t + 218.93$

a. 

[0, 17] by [0, 300]

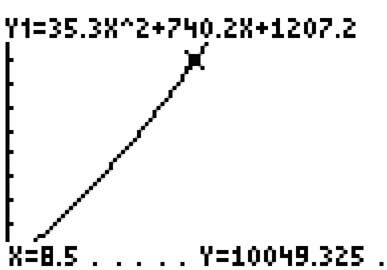
b. 

[0, 17] by [0, 300]

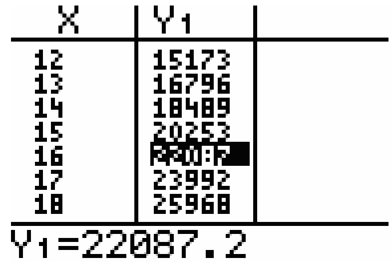
When t = 15, S = 152.255

c. 1995 corresponds to $t = 1995 - 1980 = 15$. When $t = 15$,
$S = 0.027(15)^2 - 4.85(15) + 218.93$
$= 152.255$
See the graph in part *b* above. The estimated number of osteopathic students in 1995 is 152,255.

36. $L = 35.3t^2 + 740.2t + 1207.2$

a. 

[0, 17] by [1200, 12,000]

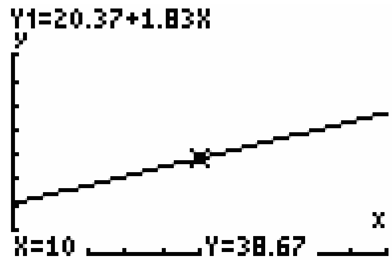
b. 

X	Y1
12	15173
13	16796
14	18489
15	20253
16	[illegible]
17	23992
18	25968

Y1=22087.2

c. The cost in 1996 is approximately \$22,087.2 million.

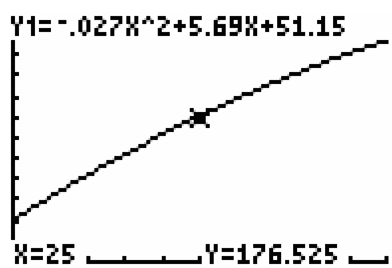
37. $B(t) = 20.37 + 1.83t$

a. 

[0, 20] by [0, 100]

b. The tax burden increased. Reading the graph from left to right, as t increases so does $B(t)$.

38. $f(x) = -0.027x^2 + 5.69x + 51.15$

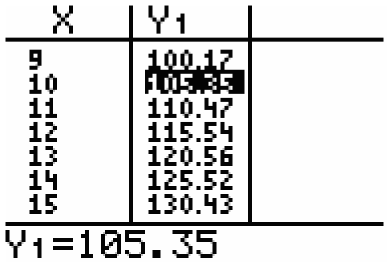
a. 

[0, 50] by [0, 300]

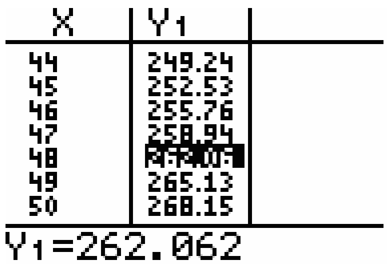
b. The graph shows years 1950 through 2000.

c. The graph is increasing between 1950 and 2000.

d.

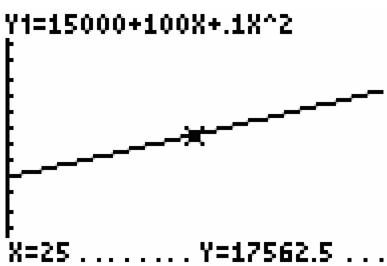


In 1960, the juvenile arrest rate is 105.35 per 100,000 people.



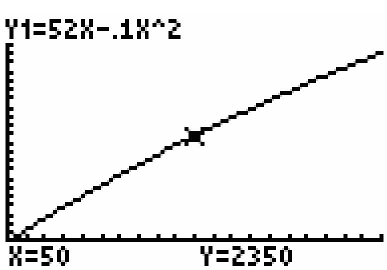
In 1998 the juvenile arrest rate is 262.062 per 100,000 people.

39. $C(x) = 15{,}000 + 100x + 0.1x^2$



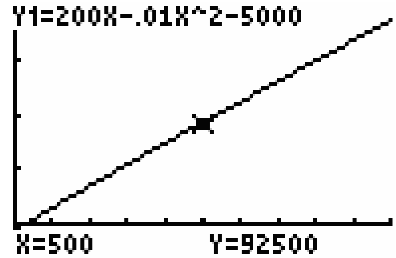
[0, 50] by [10,000, 25,000]

40. $R(x) = 52x - 0.1x^2$



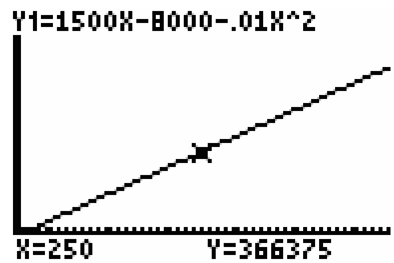
[0, 100] by [0, 5000]

41. $P(x) = 200x - 0.01x^2 - 5000$



[0, 1000] by [–25,000, 200,000]

42. $P(x) = 1500x - 8000 - 0.01x^2$



[0, 500] by [0, 1,000,000]

43. $f(t) = 982.06t + 32{,}903.77$

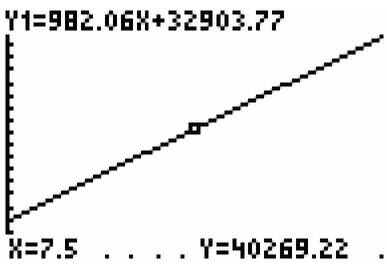
a. Since the base year is 1990, 1990-2005 correspond to values of t between 0 and 15 inclusive.

b. For 1990:

$$f(0) = 982.06(0) + 32{,}903.77$$
$$= 32{,}903.77$$

For 2005:

$$f(15) = 982.06(15) + 32{,}903.77$$
$$= 47{,}634.67$$

c. 

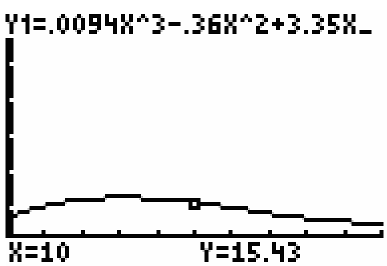
[0, 15] by [30,000, 50,000]

{Note that answers may vary.}

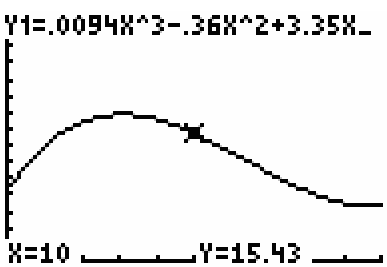
44. $y = 0.0094x^3 - 0.36x^2 + 3.35x + 8.53$

a. Since the base year is 1975, 1975-1996 correspond to values of x between 0 and 21.

b. Since percentages are between 0 and 100, y must correspond to values between 0 and 100.

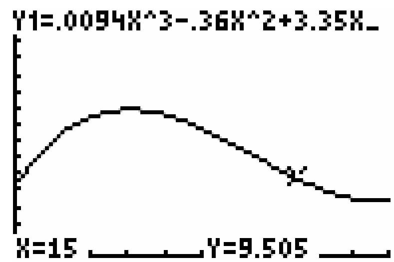
c. 

[0, 20] by [0, 100]

d. 

[0, 20] by [0, 30]

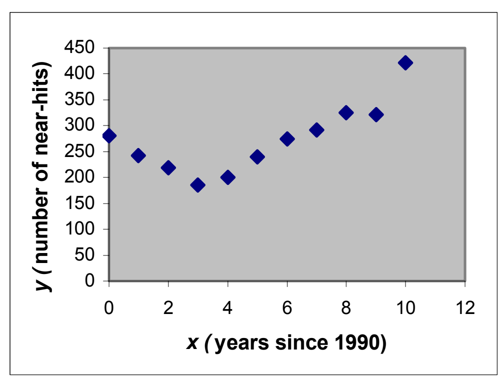
e. 1990 corresponds to $x = 1990 - 1975 = 15$.



In 1990, approximately 9.5% of high school seniors had used cocaine.

45.

x (years since 1990)	y (number of near-hits)
0	281
1	242
2	219
3	186
4	200
5	240
6	275
7	292
8	325
9	321
10	421

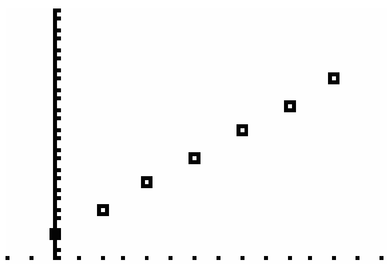


46. a. 299.9 million or 299,900,000

b.

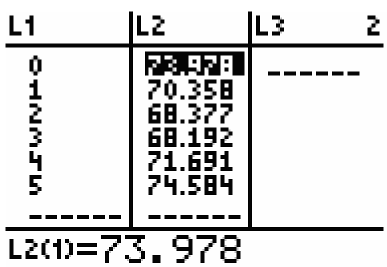
Years after 2000	Population (millions)
0	275.3
10	299.9
20	324.9
30	351.1
40	377.4
50	403.7
60	432

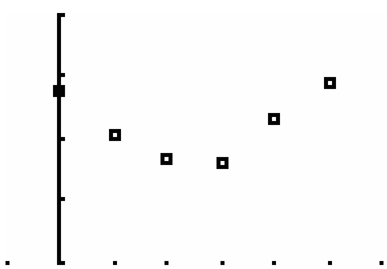
c.



[–10, 70] by [250, 500]

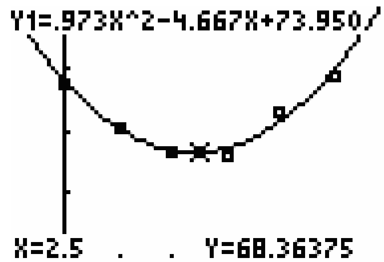
47. a.





[–1, 6] by [60, 80]

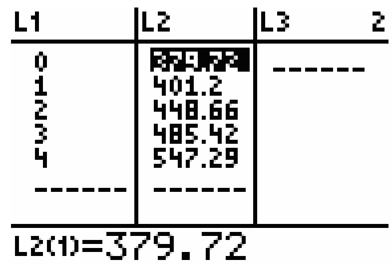
b.

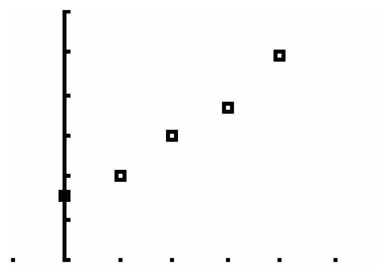


[–1, 6] by [60, 80]

Yes. The fit is reasonable but not perfect.

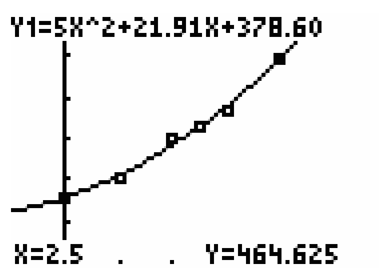
48. a.





[–1, 6] by [300, 600]

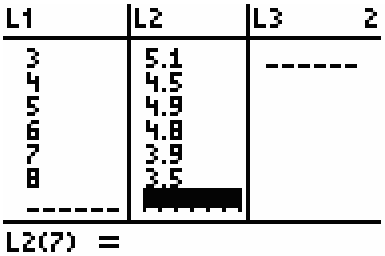
b.

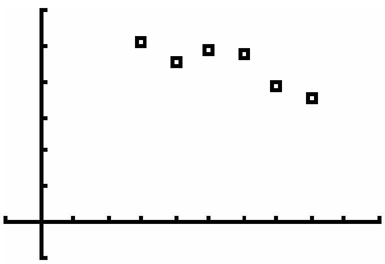


[–1, 6] by [300, 600]

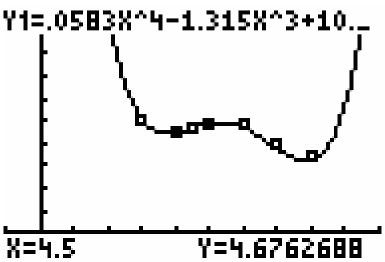
Yes. The fit is reasonable but not perfect.

49. a. In 2003 the unemployment rate was 3.5%.

b. 



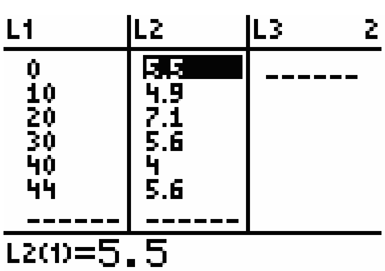
[–1, 10] by [–1, 6]

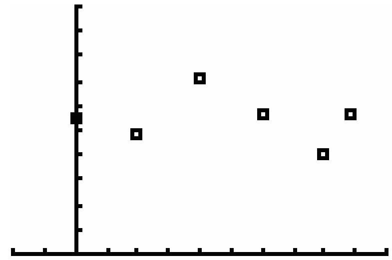
c. 

[–1, 10] by [–1, 10]

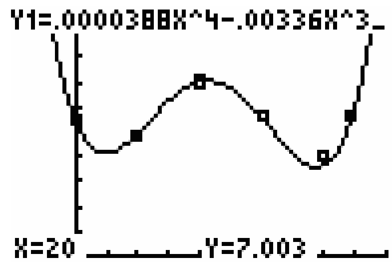
Yes. The fit is reasonable but not perfect.

50. a. The dropout rate in 2004 is 5.6%.

b. 



[–10, 50] by [0, 10]

c. 

[–10, 50] by [0, 10]

Yes. The fit is reasonable but not perfect.

Section 1.3 Skills Check

1. Recall that linear functions must be in the form $f(x) = ax + b$.

a. Not linear. The equation has a 2nd degree (squared) term.

b. Linear.

c. Not linear. The x-term is in the denominator of a fraction.

2. $m = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{-6-6}{28-4} = \dfrac{-12}{24} = -\dfrac{1}{2}$

3.
$$\begin{aligned} m &= \frac{y_2 - y_1}{x_2 - x_1} \\ &= \frac{4-(-10)}{8-8} \\ &= \frac{14}{0} \\ &= \text{undefined} \end{aligned}$$
Zero in the denominator creates an undefined expression.

4. $m = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{5-5}{-2-(-6)} = \dfrac{0}{4} = 0$

5. a. x-intercept: Let $y = 0$ and solve for x.

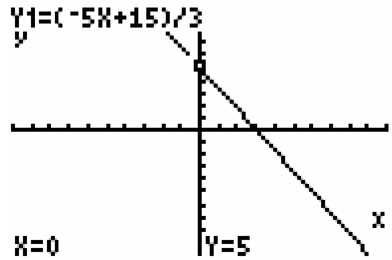
$$\begin{aligned} 5x - 3(0) &= 15 \\ 5x &= 15 \\ x &= 3 \end{aligned}$$

y-intercept: Let $x = 0$ and solve for y.

$$\begin{aligned} 5(0) - 3y &= 15 \\ -3y &= 15 \\ y &= -5 \end{aligned}$$

x-intercept: (3, 0), y-intercept: (0, –5)

b.



[–10, 10] by [–10, 10]

6. a. x-intercept: Let $y = 0$ and solve for x.

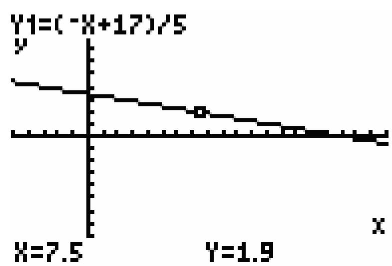
$$\begin{aligned} x + 5(0) &= 17 \\ x &= 17 \end{aligned}$$

y-intercept: Let $x = 0$ and solve for y.

$$\begin{aligned} 0 + 5y &= 17 \\ 5y &= 17 \\ y &= \frac{17}{5} \\ y &= 3.4 \end{aligned}$$

x-intercept: (17, 0), y-intercept: (0, 3.4)

b.



[–5, 20] by [–10, 10]

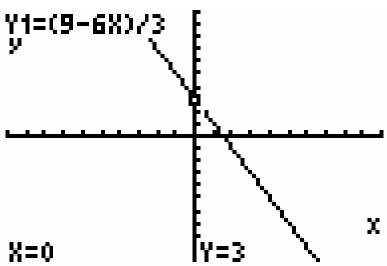
7. a. x-intercept: Let $y = 0$ and solve for x.

$3(0) = 9 - 6x$
$0 = 9 - 6x$
$0 - 9 = 9 - 9 - 6x$
$-6x = -9$
$x = \frac{-9}{-6}$
$x = \frac{3}{2} = 1.5$

y-intercept: Let $x = 0$ and solve for y.

$3y = 9 - 6(0)$
$3y = 9$
$y = 3$

x-intercept: (1.5, 0), y-intercept: (0, 3)

b. 

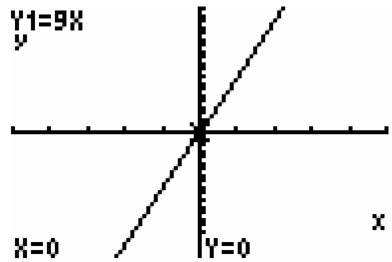
[–10, 10] by [–10, 10]

8. a. x-intercept: Let $y = 0$ and solve for x.

$0 = 9x$
$x = 0$
y-intercept: Let $x = 0$ and solve for y.

$y = 9(0)$
$y = 0$

x-intercept: (0, 0), y-intercept: (0, 0). Note that the origin, (0, 0), is both an x- and y-intercept.

b. 

[–5, 5] by [–20, 20]

9. Horizontal lines have a slope of **zero**. Vertical lines have an **undefined** slope.

10. a. Positive

b. Negative

c. Undefined

d. Zero

11. $m = 4, b = 8$

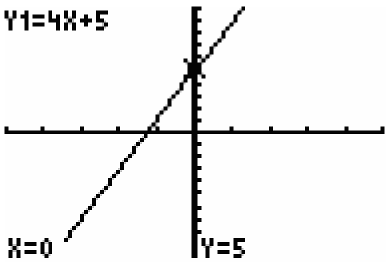
12. $3x + 2y = 7$
$\frac{2y}{2} = \frac{-3x + 7}{2}$
$y = \frac{-3x + 7}{2}$
$y = -\frac{3}{2}x + \frac{7}{2}$
$m = -\frac{3}{2}, b = \frac{7}{2}$

13. $5y = 2$
$y = \frac{2}{5}$, horizontal line
$m = 0, b = \frac{2}{5}$

14. $x = 6$, vertical line
undefined slope, no y-intercept

15. **a.** $m = 4,\ b = 5$

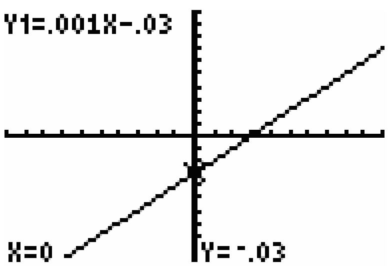
b. Rising. The slope is positive

c. 

[–5, 10] by [–5, 10]

16. **a.** $m = 0.001,\ b = -0.03$

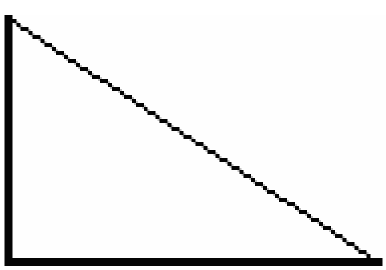
b. Rising. The slope is positive.

c. 

[–100, 100] by [–0.10, 0.10]

17. **a.** $m = -100,\ b = 50{,}000$

b. Falling. Slope is negative.

c. 

[0, 500] by [0, 50,000]

18. Steepness refers to the rise of the line as the graph is read from left to right. Therefore, exercise 17 is the least steep, followed by exercise 16. Exercise 15 displays the greatest steepness.

19. For a linear function, the rate of change is equal to the slope. $m = 4$.

20. For a linear function, the rate of change is equal to the slope. $m = \frac{1}{3}$.

21. For a linear function, the rate of change is equal to the slope. $m = -15$.

22. For a linear function, the rate of change is equal to the slope. $m = 300$.

23. For a linear function, the rate of change is equal to the slope.
$$m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{-7-3}{4-(-1)} = \frac{-10}{5} = -2.$$

24. For a linear function, the rate of change is equal to the slope.
$$m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{3-1}{6-2} = \frac{2}{4} = \frac{1}{2}.$$

25. The lines are perpendicular. The slopes are negative reciprocals of one another.

26. For line 1: $m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{8-3}{5-(-2)} = \frac{5}{7}$

For line 2: $5x-7y=35$

$$-7y=-5x+35$$
$$\frac{-7y}{-7}=\frac{-5x+35}{-7}$$
$$y=\frac{5}{7}x-5$$
$$m=\frac{5}{7}$$

Since the slopes are equal, the lines are parallel.

27. a. The identity function is $y=x$. Graph *ii* represents the identity function.

b. The constant function is $y=k$, where k is a real number. In this case, $k=3$. Graph *i* represents a constant function.

28. The slope of the identity function is one ($m=1$).

29. a. The slope of a constant function is zero ($m=0$).

b. The rate of change of a constant function equals the slope, which is zero.

30. The rate of change of the identity function equals the slope, which is one.

Section 1.3 Exercises

31. Linear. Rising—the slope is positive. $m=0.155$.

32. Non-linear. The function does not fit the form $f(x)=mx+b$.

33. Linear. Falling—the slope is negative. $m=-0.762$.

34. Linear. Falling—the slope is negative. $m=-0.356$.

35. a. x-intercept: Let p = 0 and solve for x.

$$30p-19x=30$$
$$30(0)-19x=30$$
$$-19x=30$$
$$x=-\frac{30}{19}$$

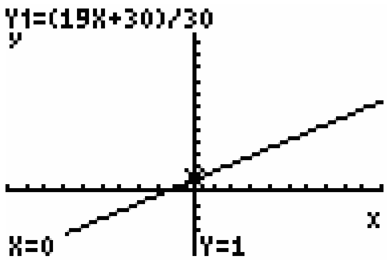
The x-intercept is $\left(-\frac{30}{19},0\right)$.

b. p-intercept: Let x = 0 and solve for p.

$$30p-19x=30$$
$$30p-19(0)=30$$
$$30p=30$$
$$p=1$$

The y-intercept is $(0,1)$.
In 1990, the percentage of high school students using marijuana daily is 1%.

c. x = 0 corresponds to 1990, x = 1 corresponds 1992, etc.



[–10, 10] by [–5, 15]

36. a. y-intercept: Let $x = 0$ and solve for y.

$$y = 828{,}000 - 2300(0) = 828{,}000$$

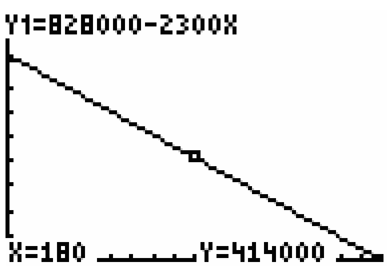
Initially the value of the building is $828,000.

b. x-intercept: Let $y = 0$ and solve for x.

$$0 = 828{,}000 - 2300x$$
$$-2300x = -828{,}000$$
$$x = \frac{-828{,}000}{-2300} = 360$$

The value of the building is zero (the building is completely depreciated) after 360 months or 30 years.

c.



[0, 360] by [0, 1,000,000]

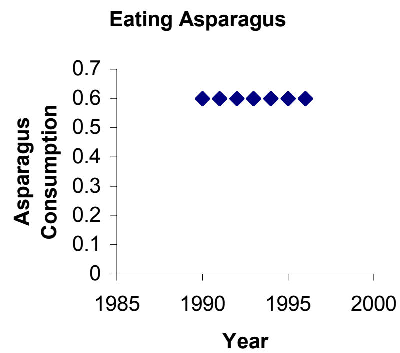
37. a. The data can be modeled by a constant function. Every input x yields the same output y.

b. $y = 11.81$

c. A constant function has a slope equal to zero.

d. For a linear function the rate of change is equal to the slope. $m = 0$.

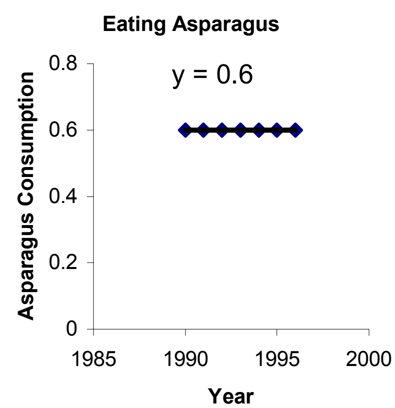
38. a.



b. The data can be modeled by a constant function.

c. $y = 0.6$

d.



39. a. $m = 26.5$

b. Each year, the percent of Fortune Global 500 firms recruiting via the Internet increased by 26.5%.

40. a. For a linear function, the rate of change is equal to the slope. $m = -0.7069$. The slope is negative.

b. The percentage is decreasing.

41. a. For a linear function, the rate of change is equal to the slope. $m=\frac{12}{7}$. The slope is positive.

b. For each one degree increase in temperature, there is a $\frac{12}{7}$ increase in the number of cricket chirps.

42. a. $m=1.834$

b. The rate of growth is 1.834 hundred dollars per year.

43. a. Yes, it is linear.

b. $m=0.959$

c. For each one dollar increase in white median annual salaries, there is a 0.959 dollar increase in minority median annual salaries.

44. a. $m=-0.3552$
For each one unit increase in x, the number of years since 1950, there is a 0.3552 decrease in y, the percent of voters voting in presidential elections.

b. The rate of decrease is 0.3552 percent per year.

45. a. To determine the slope, rewrite the equation in the form $f(x)=ax+b$ or $y=mx+b$.

$$30p-19x=30$$
$$30p=19x+30$$
$$\frac{30p}{30}=\frac{19x+30}{30}$$
$$p=\frac{19}{30}x+1$$
$$m=\frac{19}{30}\approx .633$$

b. Each year, the percentage of high school seniors using marijuana daily increases by approximately 0.63%.

46. a. $33p-18d=496$
Solving for p:
$$33p=18d+496$$
$$p=\frac{18d+496}{33}$$
$$p=\frac{18}{33}d+\frac{496}{33}$$
$$p=\frac{6}{11}d+\frac{496}{33}$$
Therefore, $m=\frac{6}{11}$

b. For every one unit increase in depth, there is a corresponding $\frac{6}{11}$ pound per square foot increase in pressure.

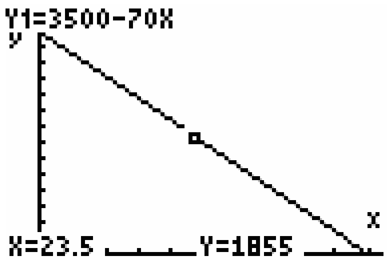
47. x-intercept: Let $R = 0$ and solve for x.

$$R=3500-70x$$
$$0=3500-70x$$
$$70x=3500$$
$$x=\frac{3500}{70}=50$$
The x-intercept is $(50,0)$.

y-intercept: Let $x = 0$ and solve for R.

$$R=3500-70x$$
$$R=3500-70(0)$$
$$R=3500$$

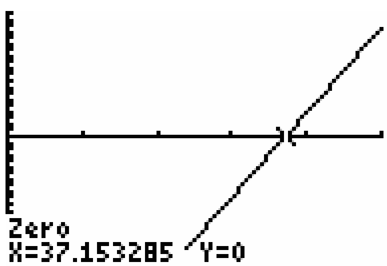
The y-intercept is $(0,3500)$.



[0, 52] by [0, 3500]

48. a. $D(50) = 0.137(50) - 5.09$
$= 1.76$
Based on the model, 50,000 ATM transactions correspond to a dollar volume of $1.76 billion.

b. Fewer than approximately 37,154 ATMs.



[0, 50] by [–2, 2]

49. a. $m = 5.74$
$y - \text{intercept} = b = 14.61$

b. The *y*-intercept represents the percentage of the population with Internet access in 1995. Therefore in 1995, 14.61% of the U.S. population had Internet access.

c. The slope represents the annual change in the percentage of the population with Internet access. Therefore, the percentage of the population with Internet access increased by 5.74% each year.

50. a. $m = 11.23$
$y - \text{intercept} = b = 6.205$

b. The *y*-intercept represents the total amount spent for wireless communications in 1995. Therefore in 1995, the amount spent on wireless communication in the U.S. was 6.205 billion dollars.

c. The slope represents the annual change in the amount spent on wireless communications. Therefore, the amount spent on wireless communications in the U.S. increased by 11.23 billion each year.

51. a.
$$m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{700{,}000 - 1{,}310{,}000}{20 - 10} = \frac{-610{,}000}{10} = -61{,}000$$

b. Based on the calculation in part a), the property value decreases by $61,000 each year. The annual rate of change is –61,000.

52. a.
$$m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{68.5 - 18.1}{1990 - 1890} = \frac{50.4}{100} = 0.504$$

b. Based on the calculation in part a), the number of men in the workforce increased by 0.504 million (or 504,000) each year.

53. Marginal profit is the rate of change of the profit function.

$$\begin{aligned} m &= \frac{y_2 - y_1}{x_2 - x_1} \\ &= \frac{9000 - 4650}{375 - 300} \\ &= \frac{4350}{75} \\ &= 58 \end{aligned}$$

The marginal profit is \$58 per unit.

54. Marginal cost is the rate of change of the cost function.

$$\begin{aligned} m &= \frac{y_2 - y_1}{x_2 - x_1} \\ &= \frac{3530 - 2690}{500 - 200} \\ &= \frac{840}{300} \\ &= 2.8 \end{aligned}$$

The marginal cost is \$2.80 per unit.

55. a. $m = 0.56$

b. The marginal cost is \$0.56 per unit.

c. Manufacturing one additional golf ball each month increases the cost by \$0.56 or 56 cents.

56. a. $m = 98$

b. The marginal cost is \$98 per unit.

c. Manufacturing one additional television each month increases the cost by \$98.

57. a. $m = 1.60$

b. The marginal revenue is \$1.60 per unit.

c. Selling one additional golf ball each month increases revenue by \$1.60.

58. a. $m = 198$

b. The marginal revenue is \$198 per unit

c. Selling one additional television each month increases revenue by \$198.

59. The marginal profit is \$19 per unit. Note that $m = 19$.

60. The marginal profit is \$939 per unit. Note that $m = 939$.

Section 1.4 Skills Check

1. $m = 4,\ b = \frac{1}{2}$. The equation is $y = 4x + \frac{1}{2}$.

2. $m = 5,\ b = \frac{1}{3}$. The equation is $y = 5x + \frac{1}{3}$.

3. $m = \frac{1}{3},\ b = 3$. The equation is $y = \frac{1}{3}x + 3$.

4. $m = -\frac{1}{2},\ b = -8$. The equation is $y = -\frac{1}{2}x - 8$.

5. $m = -\frac{3}{4},\ b = 2$. The equation is $y = -\frac{3}{4}x + 2$.

6. $m = 3,\ b = \frac{2}{5}$. The equation is $y = 3x + \frac{2}{5}$.

7. $y - y_1 = m(x - x_1)$
$y - 4 = 5(x - (-1))$
$y - 4 = 5(x + 1)$
$y - 4 = 5x + 5$
$y = 5x + 9$

8. $y - y_1 = m(x - x_1)$
$y - 3 = -\frac{1}{2}(x - (-4))$
$y - 3 = -\frac{1}{2}(x + 4)$
$y - 3 = -\frac{1}{2}x - 2$
$y = -\frac{1}{2}x + 1$

9. $y - y_1 = m(x - x_1)$
$y - (-6) = -\frac{3}{4}(x - 4)$
$y + 6 = -\frac{3}{4}x + \left(\frac{3}{4} \bullet \frac{4}{1}\right)$
$y + 6 = -\frac{3}{4}x + 3$
$y = -\frac{3}{4}x - 3$

10. $y - y_1 = m(x - x_1)$
$y - 6 = -\frac{2}{3}(x - (-3))$
$y - 6 = -\frac{2}{3}(x + 3)$
$y - 6 = -\frac{2}{3}x - 2$
$y = -\frac{2}{3}x + 4$

11. $y - y_1 = m(x - x_1)$
$y - 4 = 0(x - (-1))$
$y - 4 = 0$
$y = 4$

12. Since the slope is undefined, the line is vertical. The equation of the line is $x = a$, where a is the x-coordinate of a point on the line. Since the line passes through (–1, 4), the equation is $x = -1$.

13. $x = 9$

14. $y = -10$

15. Slope: $m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{1-7}{-2-(4)} = \frac{-6}{-6} = 1$

Equation: $$\begin{aligned} y - y_1 &= m(x - x_1) \\ y - 7 &= 1(x-4) \\ y - 7 &= x - 4 \\ y &= x + 3 \end{aligned}$$

16. Slope: $m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{8-2}{5-3} = \frac{6}{2} = 3$

Equation: $$\begin{aligned} y - y_1 &= m(x - x_1) \\ y - 8 &= 3(x-5) \\ y - 8 &= 3x - 15 \\ y &= 3x - 7 \end{aligned}$$

17. Slope: $m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{6-3}{2-(-1)} = \frac{3}{3} = 1$

Equation: $$\begin{aligned} y - y_1 &= m(x - x_1) \\ y - 6 &= 1(x-2) \\ y - 6 &= x - 2 \\ y &= x + 4 \end{aligned}$$

18. Slope: $m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{-3-4}{4-(-3)} = \frac{-7}{7} = -1$

Equation: $$\begin{aligned} y - y_1 &= m(x - x_1) \\ y - 4 &= -1(x - (-3)) \\ y - 4 &= -x - 3 \\ y &= -x + 1 \end{aligned}$$

19. Slope: $m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{5-2}{-3-(-4)} = \frac{3}{1} = 3$

Equation: $$\begin{aligned} y - y_1 &= m(x - x_1) \\ y - 5 &= 3(x - (-3)) \\ y - 5 &= 3x + 9 \\ y &= 3x + 14 \end{aligned}$$

20. Slope: $m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{-6-(-5)}{5-2} = \frac{-1}{3} = -\frac{1}{3}$

Equation: $$\begin{aligned} y - y_1 &= m(x - x_1) \\ y - (-6) &= -\frac{1}{3}(x-5) \\ y + 6 &= -\frac{1}{3}x + \frac{5}{3} \\ y &= -\frac{1}{3}x - \frac{13}{3} \end{aligned}$$

21. Slope: $m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{5-2}{9-9} = \frac{3}{0} = \text{undefined}$

The line is vertical. The equation of the line is $x = 9$.

22. Slope: $m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{2-2}{5-(-3)} = \frac{0}{8} = 0$

The line is horizontal. The equation of the line is $y = 2$.

23. With the given intercepts, the line passes through the points (–5, 0) and (0, 4). The

slope of the line is
$m=\frac{y_2-y_1}{x_2-x_1}=\frac{4-0}{0-(-5)}=\frac{4}{5}$.

Equation: $y-y_1=m(x-x_1)$

$$y-0=\frac{4}{5}(x-(-5))$$
$$y=\frac{4}{5}(x+5)$$
$$y=\frac{4}{5}x+4$$

24. With the given intercepts, the line passes through the points (4, 0) and (0, –5). The slope of the line is
$m=\frac{y_2-y_1}{x_2-x_1}=\frac{-5-0}{0-(4)}=\frac{-5}{-4}=\frac{5}{4}$.

Equation: $y-y_1=m(x-x_1)$

$$y-0=\frac{5}{4}(x-4)$$
$$y=\frac{5}{4}(x-4)$$
$$y=\frac{5}{4}x-5$$

25. Slope: $m=\frac{y_2-y_1}{x_2-x_1}=\frac{13-(-5)}{4-(-2)}=\frac{18}{6}=3$

Equation: $y-y_1=m(x-x_1)$

$$y-13=3(x-4)$$
$$y-13=3x-12$$
$$y=3x+1$$

26. Slope: $m=\frac{y_2-y_1}{x_2-x_1}=\frac{-11-7}{2-(-4)}=\frac{-18}{6}=-3$

Equation: $y-y_1=m(x-x_1)$

$$y-7=-3(x-(-4))$$
$$y-7=-3x-12$$
$$y=-3x-5$$

27. For a linear function, the rate of change is equal to the slope. Therefore, $m=-15$. The equation is

$$y-y_1=m(x-x_1)$$
$$y-12=-15(x-0)$$
$$y-12=-15x$$
$$y=-15x+12.$$

28. For a linear function, the rate of change is equal to the slope. Therefore, $m=-8$. The equation is

$$y-y_1=m(x-x_1)$$
$$y-(-7)=-8(x-0)$$
$$y+7=-8x$$
$$y=-8x-7.$$

29. $\frac{f(b)-f(a)}{b-a}$

$$=\frac{f(2)-f(-1)}{2-(-1)}$$
$$=\frac{(2)^2-(-1)^2}{3}=\frac{4-1}{3}=\frac{3}{3}=1$$

The average rate of change between the two points is 1.

30. $\frac{f(b)-f(a)}{b-a}$

$$=\frac{f(2)-f(-1)}{2-(-1)}$$
$$=\frac{(2)^3-(-1)^3}{3}=\frac{8+1}{3}=\frac{9}{3}=3$$

The average rate of change between the two points is 3.

31. a. $f(x+h) = 45 - 15(x+h)$
$= 45 - 15x - 15h$

b. $f(x+h) - f(x)$
$= 45 - 15x - 15h - [45 - 15x]$
$= 45 - 15x - 15h - 45 + 15x$
$= -15h$

c. $\dfrac{f(x+h) - f(x)}{h} = \dfrac{-15h}{h} = -15$

32. a. $f(x+h) = 32(x+h) + 12$
$= 32x + 32h + 12$

b. $f(x+h) - f(x)$
$= 32x + 32h + 12 - [32x + 12]$
$= 32x + 32h + 12 - 32x - 12$
$= 32h$

c. $\dfrac{f(x+h) - f(x)}{h} = \dfrac{32h}{h} = 32$

33. a. $f(x+h) = 2(x+h)^2 + 4$
$= 2\left(x^2 + 2xh + h^2\right) + 4$
$= 2x^2 + 4xh + 2h^2 + 4$

b. $f(x+h) - f(x)$
$= 2x^2 + 4xh + 2h^2 + 4 - \left[2x^2 + 4\right]$
$= 2x^2 + 4xh + 2h^2 + 4 - 2x^2 - 4$
$= 4xh + 2h^2$

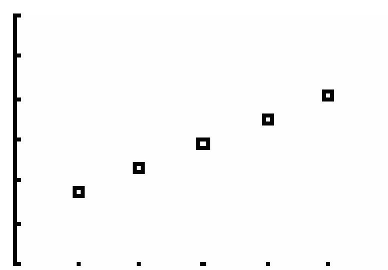
c. $\dfrac{f(x+h) - f(x)}{h}$
$= \dfrac{4xh + 2h^2}{h}$
$= \dfrac{h(4x + 2h)}{h}$
$= 4x + 2h$

34. a. $f(x+h) = 3(x+h)^2 + 1$
$= 3\left(x^2 + 2xh + h^2\right) + 1$
$= 3x^2 + 6xh + 3h^2 + 1$

b. $f(x+h) - f(x)$
$= 3x^2 + 6xh + 3h^2 + 1 - \left[3x^2 + 1\right]$
$= 3x^2 + 6xh + 3h^2 + 1 - 3x^2 - 1$
$= 6xh + 3h^2$

c. $\dfrac{f(x+h) - f(x)}{h}$
$= \dfrac{6xh + 3h^2}{h}$
$= \dfrac{h(6x + 3h)}{h}$
$= 6x + 3h$

35. a. The difference in the *y*-coordinates is consistently 30, while the difference in the *x*-coordinates is consistently 10. Note that 615–585 = 30, 645 – 630 = 30, etc. Considering the scatter plot below, a line fits the data exactly.



[0, 60] by [500, 800]

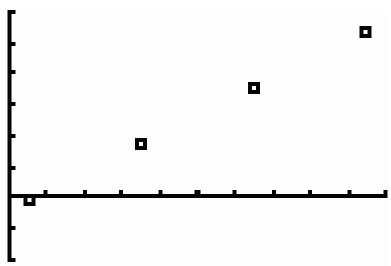
b. Slope:

$$m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{615 - 585}{20 - 10} = \frac{30}{10} = 3$$

Equation:

$$\begin{aligned} y - y_1 &= m(x - x_1) \\ y - 585 &= 3(x - 10) \\ y - 585 &= 3x - 30 \\ y &= 3x + 555 \end{aligned}$$

36. a. The difference in the y-coordinates is consistently 9, while the difference in the x-coordinates is consistently 6. Note that 17.5 – 8.5 = 9, 26.5 – 17.5 = 9, etc. Considering the scatter plot below, a line fits the data exactly.



[0, 20] by [–10, 30]

b. Slope:

$$\begin{aligned} m &= \frac{y_2 - y_1}{x_2 - x_1} \\ &= \frac{26.5 - 17.5}{19 - 13} \\ &= \frac{9}{6} \\ &= \frac{3}{2} \end{aligned}$$

Equation:

$$\begin{aligned} y - y_1 &= m(x - x_1) \\ y - 26.5 &= \frac{3}{2}(x - 19) \\ y - 26.5 &= \frac{3}{2}x - \frac{57}{2} \\ y &= \frac{3}{2}x - 29.5 + 26.5 \\ y &= \frac{3}{2}x + 3 \end{aligned}$$

Section 1.4 Exercises

37. Let x = KWh hours used and let y = monthly charge in dollars. Then the equation is $y = 0.0935x + 8.95$.

38. Let x = minutes used and let y = monthly charge in dollars. Then the equation is $y = 0.07x + 4.95$.

39. Let t = number of years, and let s = value of the machinery after t years. Then the equation is $s = 36{,}000 - 3{,}600t$.

40. Let x = age in years, and let y = hours of sleep. Then the equation is

$y = 8 + 0.25(18 - x)$.

or

$y = 8 + 4.5 - 0.25x = 12.5 - 0.25x.$

41. a. Let x = the number of years since 1996, and let P = the population of Del Webb's Sun City Hilton Head community. The linear equation modeling the population growth is $P = 705x + 198$.

b. To predict the population in 2002, let $x = 2002 - 1996 = 6$. The predicted population is $P = 705(6) + 198 = 4428$.

42. Let x = the number of years past 1994, and let y = the composite SAT score for the Beaufort County School District. The linear equation modeling the change in SAT score is $P = 952 + 0.51x$.

43. a. From year 0 to year 5, the automobile depreciates from a value of $26,000 to a value of $1,000. Therefore, the total depreciation is 26,000–1000 or $25,000.

b. Since the automobile depreciates for 5 years in a straight-line (linear) fashion, each year the value declines by $\frac{25,000}{5} = \$5,000$.

c. Let t = the number of years, and let s = the value of the automobile at the end of t years. Then, based on parts a) and b) the linear equation modeling the depreciation is $s = -5000t + 26,000$.

44. $P = 2.5\%(75,000)y = 1875y$
where y = number of years
of service and P = annual pension
amount in dollars.

45. Notice that the x and y values are always match. That is the number of deputies always equals the number of patrol cars. Therefore the equation is $y = x$, where x represents the number of deputies, and y represents the number of patrol cars.

46. Notice that the y values are always the same, regardless of the x value. That is, the premium is constant. Therefore the equation is $y = 11.81$, where x represents age, and y represents the premium in dollars.

47.
$$
\begin{aligned}
m &= \frac{y_2 - y_1}{x_2 - x_1} \\
&= \frac{9000 - 4650}{375 - 300} \\
&= \frac{4350}{75} = 58
\end{aligned}
$$

Equation:
$$
\begin{aligned}
y - y_1 &= m(x - x_1) \\
y - 4650 &= 58(x - 300) \\
y - 4650 &= 58x - 17,400 \\
y &= 58x - 12,750
\end{aligned}
$$

48.
$$
\begin{aligned}
m &= \frac{y_2 - y_1}{x_2 - x_1} \\
&= \frac{3530 - 2680}{500 - 200} \\
&= \frac{850}{300} = \frac{17}{6}
\end{aligned}
$$

Equation:
$$
\begin{aligned}
y - y_1 &= m(x - x_1) \\
y - 2680 &= \frac{17}{6}(x - 200) \\
y - 2680 &= \frac{17}{6}x - \frac{1700}{3} \\
y &= \frac{17}{6}x - \frac{1700}{3} + \frac{8040}{3} \\
y &= \frac{17}{6}x - \frac{6340}{3} \\
y &\approx 2.33x - 2113.33
\end{aligned}
$$

49.
$$
\begin{aligned}
m &= \frac{y_2 - y_1}{x_2 - x_1} \\
&= \frac{700,000 - 1,310,000}{20 - 10} \\
&= \frac{-610,000}{10} \\
&= -61,000
\end{aligned}
$$

Equation:
$$
\begin{aligned}
y - y_1 &= m(x - x_1) \\
y - 1,920,000 &= -61,000(x - 0) \\
y - 1,920,000 &= -61,000x \\
y &= -61,000x + 1,920,000 \\
v &= -61,000x + 1,920,000
\end{aligned}
$$

50. a. At $t = 0$, $y = 860{,}000$.

b. $(0,860,000),(25,0)$

$$m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{0 - 860,000}{25 - 0} = \frac{-860,000}{25} = -34,400$$

Equation:

$$y - y_1 = m(x - x_1)$$
$$y - 0 = -34,400(x - 25)$$
$$y = -34,400x + 860,000$$
$$y = 860,000 - 34,400t$$

where t = number of years, y = value

51. $$m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{32.1 - 32.7}{26 - 6} = \frac{-0.6}{20} = -0.03$$

Equation:

$$y - y_1 = m(x - x_1)$$
$$y - 32.7 = -0.03(x - 6)$$
$$y - 32.7 = -0.03x + 0.18$$
$$y = -0.03x + 32.88$$
$$p = 32.88 - 0.03t$$

where t = number of years beyond 1975, y = percentage of cigarette use

52. Let x = median weekly income for whites, and y = median weekly income for blacks. The goal is to write $y = f(x)$.

$$m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{\text{change in } y}{\text{change in } x} = \frac{61.90}{100} = 0.619$$

Equation:

$$y - y_1 = m(x - x_1)$$
$$y - 527 = 0.619(x - 676)$$
$$y - 527 = 0.619x - 418.444$$
$$y = 0.619x + 108.556$$

53. a. Notice that the change in the x-values is consistently 1 while the change in the y-values is consistently 0.05. Therefore the table represents a linear function. The rate of change is the slope of the linear function.

$$m = \frac{\text{vertical change}}{\text{horizontal change}} = \frac{0.05}{1} = 0.05$$

b. Let x = the number of drinks, and let y = the blood alcohol content. Using points (0, 0) and (1, 0.05), the slope is

$$m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{0.05 - 0}{1 - 0} = \frac{0.05}{1} = 0.05.$$

Equation:

$$y - y_1 = m(x - x_1)$$
$$y - 0 = 0.05(x - 0)$$
$$y = 0.05x$$

54. a. Notice that the change in the x-values is consistently 1 while the change in the y-values is consistently 0.02. Therefore the table represents a linear function. The rate of change is the slope of the linear function.

$$m = \frac{\text{vertical change}}{\text{horizontal change}} = \frac{0.02}{1} = 0.02$$

b. Let x = the number of drinks, and let y = the blood alcohol content. Using points (5, 0.11) and (10, 0.21), the slope is

$$m = \frac{y_2 - y_1}{x_2 - x_1}$$
$$= \frac{0.21 - 0.11}{10 - 5}$$
$$= \frac{0.10}{5} = 0.02.$$

Equation:

$$y - y_1 = m(x - x_1)$$
$$y - 0.11 = 0.02(x - 5)$$
$$y - 0.11 = 0.02x - 0.1$$
$$y = 0.02x + 0.01$$

55. a. Let x = the year at the beginning of the decade, and let y = average number of men in the workforce during the decade. Using points (1890, 18.1) and (1990, 68.5) to calculate the slope yields:

$$m = \frac{y_2 - y_1}{x_2 - x_1}$$
$$= \frac{68.5 - 18.1}{1990 - 1890}$$
$$= \frac{50.4}{100} = 0.504$$

Equation:

$$y - y_1 = m(x - x_1)$$
$$y - 18.1 = 0.504(x - 1890)$$
$$y - 18.1 = 0.504x - 952.56$$
$$y - 18.1 + 18.1 = 0.504x - 952.56 + 18.1$$
$$y = 0.504x - 934.46$$

b. Yes. Consider the following table of values based on the equation in comparison to the actual data points.

x	y (Equation Values)	Actual Values
1890	18.1	18.1
1900	23.14	22.6
1910	28.18	27
1920	33.22	32
1930	38.26	37
1940	43.3	40
1950	48.34	42.8
1960	53.38	47
1970	58.42	51.6
1980	63.46	61.4
1990	68.5	68.5

c. It is the same since the points $(1890, 18.1)$ and $(1990, 68.5)$ were used to calculate the slope of the linear model.

56. a. Let t = the year, and let p = the percentage of workers in farm occupations. Using points (1820, 78.1) and (1994, 2.6) to calculate the slope yields:

$$m = \frac{y_2 - y_1}{x_2 - x_1}$$
$$= \frac{2.6 - 71.8}{1994 - 1820}$$
$$= \frac{-69.2}{174}$$
$$= -0.3977011494 \approx -0.40$$

Equation:

$$y - y_1 = m(x - x_1)$$
$$y - 2.6 = -0.3977011494(x - 1994)$$
$$y - 2.6 = -0.3977011494x + 793.0160919$$
$$y = -0.3977011494x + 795.6160919$$
$$y \approx -0.40x + 795.62$$

b. The line appears to be a reasonable fit to the data.

c. Each year between 1890 and 1994, the percentage of workers in farm-related jobs decreases by 0.40%

d. No. The percentage of farm workers would become negative.

57. a. $$\frac{f(b)-f(a)}{b-a} = \frac{f(2001)-f(1996)}{2001-1996} = \frac{40.1-23}{5} = \frac{17.1}{5} = 3.42$$

The average rate of change is \$3.42 billion dollars per year.

b. $$m = \frac{y_2-y_1}{x_2-x_1} = \frac{40.1-23}{2001-1996} = \frac{17.1}{5} = 3.42$$

c. No. Note that change in education spending from one year to the next is not constant. It varies.

d. No. Since the change in the y-values is not constant for constant changes in the x-values, the data can not be modeled exactly by a linear function.

58. a. $$m = \frac{y_2-y_1}{x_2-x_1} = \frac{6704-5664}{2005-2000} = \frac{1040}{5} = 208$$

b. The average rate of change is 208 students per year. It is the same as part a).

c. Since enrollment is projected to increase, additional buildings may be necessary.

59. a. $$m = \frac{y_2-y_1}{x_2-x_1} = \frac{76-15}{46-10} = \frac{61}{36} = 1.69\overline{4} \approx 1.69$$

b. It is the same as part a).

c. Each year between 1960 and 1996, the percentage of out-of-wedlock teenage births increased by approximately 1.69%.

d. $$y - y_1 = m(x - x_1)$$
$$y - 15 = \frac{61}{36}(x-10)$$
$$y - 15 = \frac{61}{36}x - \frac{610}{36}$$
$$y = \frac{61}{36}x - \frac{610}{36} + 15$$
$$y = \frac{61}{36}x - \frac{610}{36} + \frac{540}{36}$$
$$y = \frac{61}{36}x - \frac{70}{36}$$
$$y \approx 1.69x - 1.94$$

60. a. $$m = \frac{y_2-y_1}{x_2-x_1} = \frac{55.1-63.1}{1992-1960} = \frac{-8}{32} = -0.25$$

b. It is the same as part a). The percentage of eligible people voting in presidential elections is decreasing at a rate of 0.25% per year.

c. $$\begin{aligned} y - y_1 &= m(x - x_1) \\ y - 63.1 &= -0.25(x - 1960) \\ y - 63.1 &= -0.25x + 490 \\ y &= -0.25x + 553.1 \end{aligned}$$

61. a. $$\begin{aligned} &\frac{f(b)-f(a)}{b-a} \\ &= \frac{f(1997)-f(1960)}{1997-1960} \\ &= \frac{1{,}197{,}590 - 212{,}953}{1997-1960} \\ &= \frac{984{,}637}{37} \\ &\approx 26{,}611.8 \end{aligned}$$

b. The slope of the line connecting the two points is the same as the average rate of change between the two points. Based on part a), $m \approx 26{,}611.8$.

c. The equation of the secant line is given by:

$$\begin{aligned} y - y_1 &= m(x - x_1) \\ y - 212{,}953 &= \frac{984{,}637}{37}(x - 1960) \\ y - 212{,}953 &\approx 26{,}611.8x - 52{,}159{,}149 \\ y &= 26{,}611.8x - 51{,}946{,}196 \end{aligned}$$

d. No. The points on the scatter plot do not approximate a linear pattern.

e. Points corresponding to 1990 and 1997. The points between those two years do approximate a linear pattern.

62. a. $$\begin{aligned} &\frac{f(b)-f(a)}{b-a} \\ &= \frac{f(5)-f(1)}{5-1} \\ &= \frac{1492-1083}{4} \\ &= \frac{409}{4} \\ &= 102.25 \end{aligned}$$

b. Each year from year 1 to year 5, the worth of the investment increases on average by $102.25.

c. The slope is the same as the average rate of change, 102.25.

d. $$\begin{aligned} y - y_1 &= m(x - x_1) \\ y - 1083 &= 102.25(x - 1) \\ y - 1083 &= 102.25x - 102.25 \\ y &= 102.25 + 980.75 \end{aligned}$$

63. a. No.

b. Yes. The points seem to follow a straight line pattern for years between 2010 and 2030.

c. $$\begin{aligned} &\frac{f(b)-f(a)}{b-a} \\ &= \frac{f(2030)-f(2010)}{2030-2010} \\ &= \frac{2.2-3.9}{2030-2010} \\ &= \frac{-1.7}{20} \\ &= -0.085 \end{aligned}$$

d. $$\begin{aligned} y - y_1 &= m(x - x_1) \\ y - 3.9 &= -0.085(x - 2010) \\ y - 3.9 &= -0.085x + 170.85 \\ y &= -0.085x + 174.75 \end{aligned}$$

64. a. No. The points in the scatter plot do not lie approximately in a line.

b. $$\frac{f(b)-f(a)}{b-a} = \frac{f(1950)-f(1890)}{1950-1890} = \frac{16.443-3.704}{60} = \frac{12.739}{60} \approx 0.2123$$

c. $$\frac{f(b)-f(a)}{b-a} = \frac{f(1990)-f(1950)}{1990-1950} = \frac{59.531-16.443}{40} = \frac{43.088}{40} = 1.0772$$

d. Yes. Since the graph curves, the average rate of change is not constant. The points do not lie exactly along a line.

65. a. Let x = the number of years since 1950, and let y = the U.S. population in thousands. Then, the average rate of change in U.S. population, in thousands, between 1950 and 1995 is given by:

$$\frac{f(b)-f(a)}{b-a} = \frac{f(45)-f(0)}{45-0} = \frac{263,044-152,271}{45-0} = \frac{110,773}{45} \approx 2461.6$$

Changing the units from thousands to millions yields $\frac{2,461.8}{1,000} = 2.4616$ million per year.

b. Remember to change the units into millions:

$$y - y_1 = m(x - x_1)$$
$$y - 152.271 = 2.4616(x - 0)$$
$$y - 152.271 = 2.4616x$$
$$y = 2.4616x - 152.271$$

c. 1975 corresponds to x = 25.
$$y = 2.4616(25) + 152.271$$
$$y = 213.811 \text{ or } 213,811,000$$

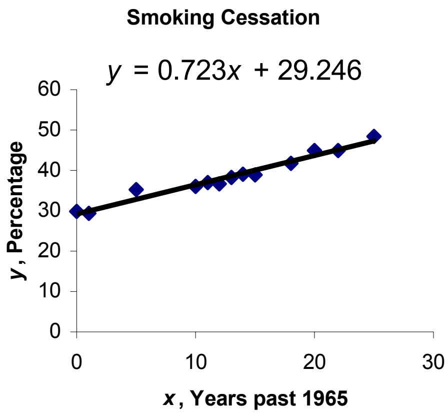
No. The values are different.

d. The table can not be represented exactly by a linear function.

66. a.

Years past 1965	Percent
0	29.8
1	29.3
5	35.2
10	36
11	37
12	36.6
13	38.3
14	39
15	38.9
18	41.8
20	45
22	44.9
25	48.4

b.



c. Yes. A linear model seems to fit the data reasonably well.

67. a. Yes. The x-values have a constant change of \$50, while the y-values have a constant change of \$14.

b. Since the table represents a linear function, the rate of change is the slope.

$$m = \frac{y_2 - y_1}{x_2 - x_1}$$
$$= \frac{5217 - 5203}{30{,}050 - 30{,}000}$$
$$= \frac{14}{50} = 0.28$$

For every \$1.00 in income, taxes increase by \$0.28.

c. Equation:

$$y - y_1 = m(x - x_1)$$
$$y - 5{,}203 = 0.28(x - 30{,}000)$$
$$y - 5{,}203 = 0.28x - 8400$$
$$y = 0.28x - 3{,}197$$

d. When x = 30,100,
$y = 0.28(30{,}100) - 3197 = 5231$.
When x = 30,300,
$y = 0.28(30{,}300) - 3197 = 5287$.

Yes. The results from the equation match with the table.

68. a. Group 1 Expense + Group 2 Expense = Total Expense

$$300x + 200y = 100{,}000$$

b.
$$300x + 200y = 100{,}000$$
$$200y = -300x + 100{,}000$$
$$y = \frac{-300x + 100{,}000}{200}$$
$$y = \frac{-300}{200}x + \frac{100{,}000}{200}$$
$$y = -1.5x + 500$$

The y-intercept is 500. If no clients from the first group are served, then 500 clients from the second group can be served. The slope is –1.5. For each one person increase in the number of clients served from the first group there is a corresponding decrease of 1.5 clients served from the second group.

c. $10 \bullet -1.5 = -15$

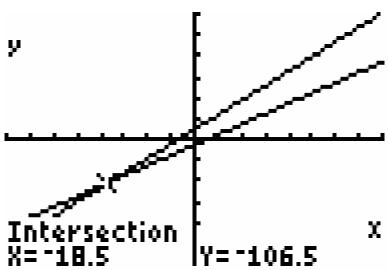
Fifteen fewer clients can be served from the second group.

Section 1.5 Skills Check

1.

$$5x-14=23+7x$$
$$5x-7x-14=23+7x-7x$$
$$-2x-14=23$$
$$-2x-14+14=23+14$$
$$-2x=37$$
$$\frac{-2x}{-2}=\frac{37}{-2}$$
$$x=-\frac{37}{2}$$
$$x=-18.5$$

Applying the intersections of graphs method, graph $y=5x-14$ and $y=23+7x$. Determine the intersection point from the graph:



[–35, 35] by [–200, 200]

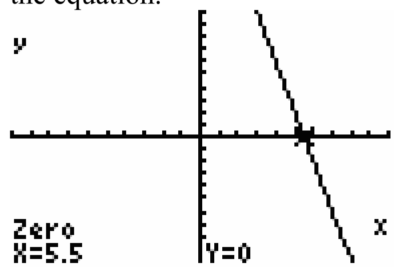
2.

$$3x-2=7x-24$$
$$3x-7x-2=7x-7x-24$$
$$-4x-2=-24$$
$$-4x=-22$$
$$\frac{-4x}{-4}=\frac{-22}{-4}$$
$$x=\frac{-22}{-4}$$
$$x=\frac{11}{2}=5.5$$

Applying the x-intercept method, rewrite the equation so that 0 appears on one side of the equal sign.

$$3x-2=7x-24$$
$$3x-7x-2+24=0$$
$$-4x+22=0$$

Graph $y=-4x+22$ and determine the x-intercept. The x-intercept is the solution to the equation.

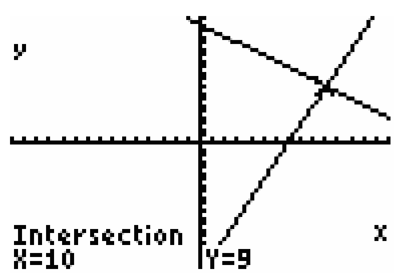


[–10, 10] by [–10, 10]

3.

$$3(x-7)=19-x$$
$$3x-21=19-x$$
$$3x+x-21=19-x+x$$
$$4x-21=19$$
$$4x-21+21=19+21$$
$$4x=40$$
$$\frac{4x}{4}=\frac{40}{4}$$
$$x=10$$

Applying the intersections of graphs method yields:



[–15, 15] by [–20, 20]

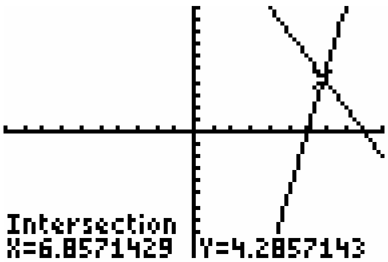
4. $5(y-6)=18-2y$

$5y-30=18-2y$

$7y=48$

$y=\frac{48}{7}$

Applying the intersections of graphs method yields:



[–10, 10] by [–10, 10]

5. $x-\frac{5}{6}=3x+\frac{1}{4}$

$LCM:12$

$12\left(x-\frac{5}{6}\right)=12\left(3x+\frac{1}{4}\right)$

$12x-10=36x+3$

$12x-36x-10=36x-36x+3$

$-24x-10=3$

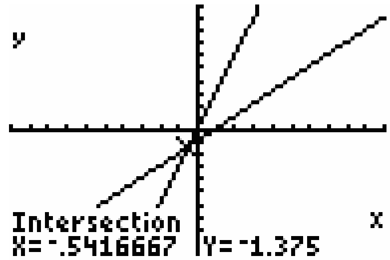
$-24x-10+10=3+10$

$-24x=13$

$\frac{-24x}{-24}=\frac{13}{-24}$

$x=-\frac{13}{24}$

Applying the intersections of graphs method yields:



[–10, 10] by [–10, 10]

6. $3x-\frac{1}{3}=5x+\frac{3}{4}$

$LCM:12$

$12\left(3x-\frac{1}{3}\right)=12\left(5x+\frac{3}{4}\right)$

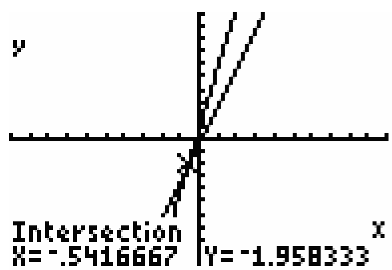
$36x-4=60x+9$

$-24x-4=9$

$-24x=13$

$x=-\frac{13}{24}$

Applying the intersections of graphs method yields:



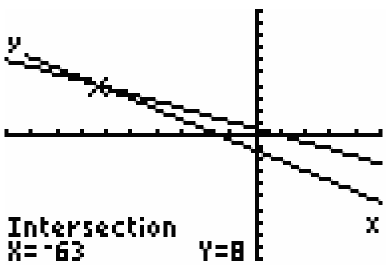
[–10, 10] by [–10, 10]

7. $\frac{5(x-3)}{6}-x=1-\frac{x}{9}$

$LCM:18$

$$18\left(\frac{5(x-3)}{6}-x\right)=18\left(1-\frac{x}{9}\right)$$
$$15(x-3)-18x=18-2x$$
$$15x-45-18x=18-2x$$
$$-3x-45=18-2x$$
$$-1x-45=18$$
$$-1x=63$$
$$x=-63$$

Applying the intersections of graphs method yields:



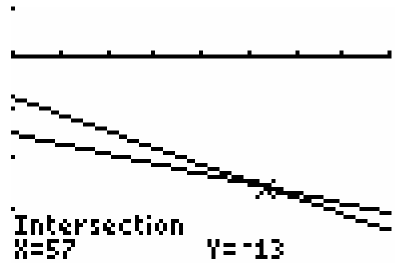
[–100, 50] by [–20, 20]

8. $\frac{4(y-2)}{5}-y=6-\frac{y}{3}$

$LCM:15$

$$15\left[\frac{4(y-2)}{5}-y\right]=15\left[6-\frac{y}{3}\right]$$
$$3\left[4(y-2)\right]-15y=90-5y$$
$$12(y-2)-15y=90-5y$$
$$12y-24-15y=90-5y$$
$$-3y-24=90-5y$$
$$2y=114$$
$$y=57$$

Applying the intersections of graphs method yields:

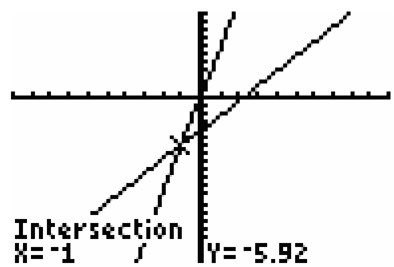


[30, 70] by [–20, 5]

9. $5.92t=1.78t-4.14$

$$5.92t-1.78t=-4.14$$
$$4.14t=-4.14$$
$$\frac{4.14t}{4.14}=\frac{-4.14}{4.14}$$
$$t=-1$$

Applying the intersections of graphs method yields:

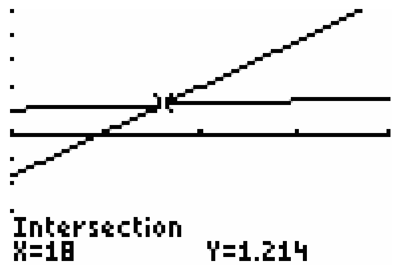


[–10, 10] by [–20, 10]

10. $0.023x+0.8=0.36x-5.266$

$$-0.337x=-6.066$$
$$x=\frac{-6.066}{-0.337}$$
$$x=18$$

Applying the intersections of graphs method yields:



[10, 30] by [–5, 5]

11. $\frac{3}{4}+\frac{1}{5}x-\frac{1}{3}=\frac{4}{5}x$

$LCM = 60$

$60\left(\frac{3}{4}+\frac{1}{5}x-\frac{1}{3}\right)=60\left(\frac{4}{5}x\right)$

$45+12x-20=48x$

$-36x=-25$

$x=\frac{-25}{-36}=\frac{25}{36}$

12. $\frac{2}{3}x-\frac{6}{5}=\frac{1}{2}+\frac{5}{6}x$

$LCM = 30$

$30\left(\frac{2}{3}x-\frac{6}{5}\right)=30\left(\frac{1}{2}+\frac{5}{6}x\right)$

$20x-36=15+25x$

$-5x=51$

$x=\frac{51}{-5}=-\frac{51}{5}$

13. Answers a), b), and c) are the same. Let $f(x)=0$ and solve for *x*.

$32+1.6x=0$

$1.6x=-32$

$x=-\frac{32}{1.6}$

$x=-20$

The solution to $f(x)=0$, the *x*-intercept of the function, and the zero of the function are all –20.

14. Answers a), b), and c) are the same. Let $f(x)=0$ and solve for *x*.

$15x-60=0$

$15x=60$

$x=4$

The solution to $f(x)=0$, the *x*-intercept of the function, and the zero of the function are all 4.

15. Answers a), b), and c) are the same. Let $f(x)=0$ and solve for *x*.

$\frac{3}{2}x-6=0$

$LCM:2$

$2\left(\frac{3}{2}x-6\right)=2(0)$

$3x-12=0$

$3x=12$

$x=4$

The solution to $f(x)=0$, the *x*-intercept of the function, and the zero of the function are all 4.

16. Answers a), b), and c) are the same. Let $f(x)=0$ and solve for *x*.

$\frac{x-5}{4}=0$

$LCM:4$

$4\left(\frac{x-5}{4}\right)=4(0)$

$x-5=0$

$x=5$

The solution to $f(x)=0$, the x-intercept of the function, and the zero of the function are all 5.

17. a. The x-intercept is 2, since an input of 2 creates an output of 0 in the function.

b. The y-intercept is –34, since the output of –34 corresponds with an input of 0.

c. The solution to $f(x)=0$ is equal to the x-intercept position for the function. Therefore, the solution to $f(x)=0$ is 2.

18. a. The x-intercept is –0.5, since an input of –0.5 creates an output of 0 in the function.

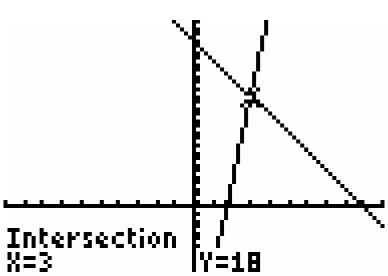
b. The y-intercept is 17, since the output of 17 corresponds with an input of 0.

c. The solution to $f(x)=0$ is equal to the x-intercept position for the function. Therefore, the solution to $f(x)=0$ is 2.

19. The answers to a) and b) are the same. The graph crosses the x-axis at x = 40.

20. The answers to a) and b) are the same. The graph crosses the x-axis at x = 0.8.

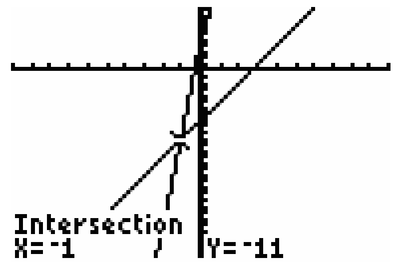
21. Applying the intersections of graphs method yields:



[–10, 10] by [–10. 30]

The solution is the x-coordinate of the intersection point or $x=3$.

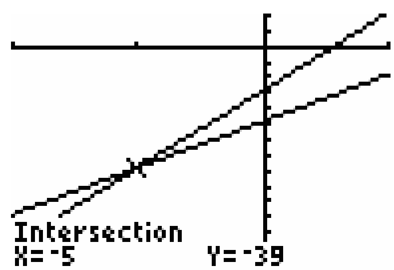
22. Applying the intersections of graphs method yields:



[–10, 10] by [–30. 10]

The solution is the x-coordinate of the intersection point or $x=-1$.

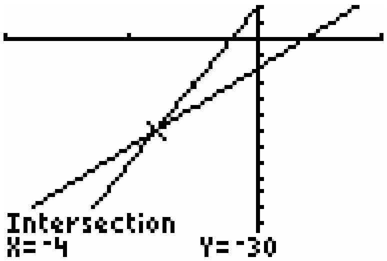
23. Applying the intersections of graphs method yields:



[–10, 5] by [–70, 10]

The solution is the x-coordinate of the intersection point or $s=-5$.

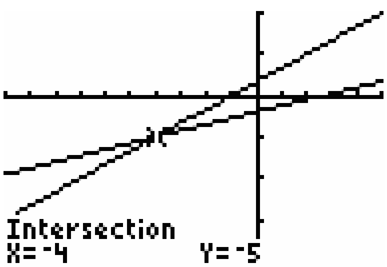
24. Applying the intersections of graphs method yields:



[–10, 5] by [–70, 10]

The solution is the *x*-coordinate of the intersection point or $x = -4$.

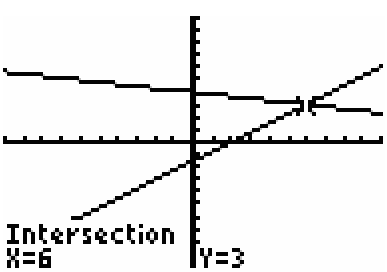
25. Applying the intersections of graphs method yields:



[–10, 5] by [–20, 10]

The solution is the *x*-coordinate of the intersection point. $t = -4$.

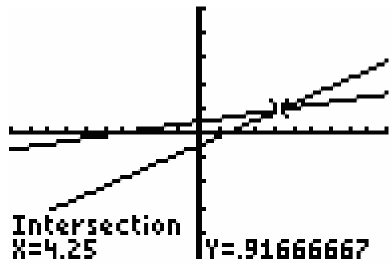
26. Applying the intersections of graphs method yields:



[–10, 10] by [–10, 10]

The solution is the *x*-coordinate of the intersection point or $x = 6$.

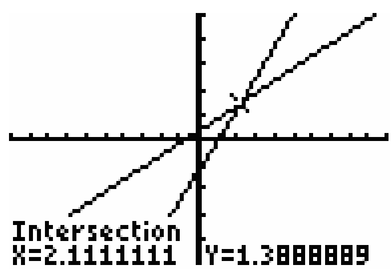
27. Applying the intersections of graphs method yields:



[–10, 10] by [–5, 5]

The solution is the *x*-coordinate of the intersection point, which is $x = 4.25 = \frac{17}{4}$.

28. Applying the intersections of graphs method yields:



[–10, 10] by [–5, 5]

The solution is the *x*-coordinate of the intersection point, which is $x = 2.\overline{1} = \frac{19}{9}$.

29. a.
$$A = P(1 + rt)$$
$$A = P + Prt$$
$$A - P = P - P + Prt$$
$$A - P = Prt$$
$$\frac{A - P}{Pr} = \frac{Prt}{Pr}$$
$$\frac{A - P}{Pr} = t \text{ or } t = \frac{A - P}{Pr}$$

b.
$$A = P(1 + rt)$$
$$\frac{A}{1 + rt} = \frac{P(1 + rt)}{1 + rt}$$
$$\frac{A}{1 + rt} = P \text{ or } P = \frac{A}{1 + rt}$$

30. $V = \frac{1}{3}\pi r^2 h$

$LCM : 3$
$$3(V) = 3\left(\frac{1}{3}\pi r^2 h\right)$$
$$3V = \pi r^2 h$$
$$\frac{3V}{\pi r^2} = \frac{\pi r^2 h}{\pi r^2}$$
$$\frac{3V}{\pi r^2} = h \text{ or } h = \frac{3V}{\pi r^2}$$

31. $5F - 9C = 160$
$$5F - 9C + 9C = 160 + 9C$$
$$5F = 160 + 9C$$
$$\frac{5F}{5} = \frac{160 + 9C}{5}$$
$$F = \frac{9}{5}C + \frac{160}{5}$$
$$F = \frac{9}{5}C + 32$$

32. $4(a - 2x) = 5x + \frac{c}{3}$

$LCM : 3$
$$3\big(4(a - 2x)\big) = 3\left(5x + \frac{c}{3}\right)$$
$$12(a - 2x) = 15x + c$$
$$12a - 24x = 15x + c$$
$$12a - 24x - 15x = 15x - 15x + c$$
$$12a - 39x = c$$
$$12a - 12a - 39x = c - 12a$$
$$-39x = c - 12a$$
$$x = \frac{c - 12a}{-39} \text{ or}$$
$$x = \left(\frac{-1}{-1}\right)\left(\frac{c - 12a}{-39}\right) = \frac{12a - c}{39}$$

33. $\frac{P}{2} + A = 5m - 2n$

$LCM : 2$
$$2\left(\frac{P}{2} + A\right) = 2(5m - 2n)$$
$$P + 2A = 10m - 4n$$
$$P + 2A - 10m = 10m - 4n - 10m$$
$$\frac{P + 2A - 10m}{-4} = \frac{-4n}{-4}$$
$$\frac{P + 2A - 10m}{-4} = n$$
$$n = \frac{P}{-4} + \frac{2A}{-4} - \frac{10m}{-4}$$
$$n = \frac{5m}{2} - \frac{P}{4} - \frac{A}{2}$$

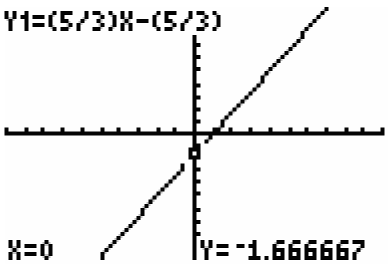
34. $y - y_1 = m(x - x_1)$
$$y - y_1 = mx - mx_1$$
$$y - y_1 + mx_1 = mx - mx_1 + mx_1$$
$$\frac{y - y_1 + mx_1}{m} = \frac{mx}{m}$$
$$x = \frac{y - y_1 + mx_1}{m}$$

35. $5x - 3y = 5$

$$-3y = -5x + 5$$

$$y = \frac{-5x+5}{-3}$$

$$y = \frac{5}{3}x - \frac{5}{3}$$



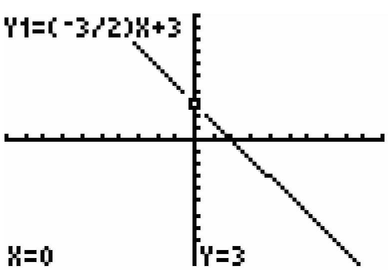
[–10, 10] by [–10, 10]

36. $3x + 2y = 6$

$$2y = -3x + 6$$

$$y = \frac{-3x+6}{2}$$

$$y = -\frac{3}{2}x + 3$$



[–10, 10] by [–10, 10]

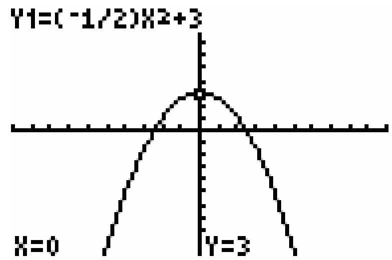
37. $x^2 + 2y = 6$

$$2y = 6 - x^2$$

$$y = \frac{6 - x^2}{2}$$

$$y = 3 - \frac{1}{2}x^2 \text{ or}$$

$$y = -\frac{1}{2}x^2 + 3$$



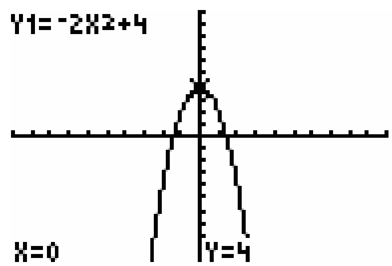
[–10, 10] by [–10, 10]

38. $4x^2 + 2y = 8$

$$2y = -4x^2 + 8$$

$$y = \frac{-4x^2+8}{2}$$

$$y = -2x^2 + 4$$



[–10, 10] by [–10, 10]

Section 1.5 Exercises

39. Let y = 690,000 and solve for x.

$$690,000 = 828,000 - 2300x$$
$$-138,000 = -2300x$$
$$x = \frac{-138,000}{-2300}$$
$$x = 60$$

After 60 months or 5 years the value of the building will be $690,000.

40. Let C = 20 and solve for F.

$$5F - 9C = 160$$
$$5F - 9(20) = 160$$
$$5F - 180 = 160$$
$$5F = 340$$
$$F = \frac{340}{5} = 68$$

68° Fahrenheit equals 20° Celsius.

41. $S = P(1 + rt)$

$$9000 = P(1 + (0.10)(5))$$
$$9000 = P(1 + 0.50)$$
$$9000 = 1.5P$$
$$P = \frac{9000}{1.5} = 6000$$

$6000 must be invested as the principal.

42. $I = t - 0.55(1-h)(t-58)$

$$79 = 80 - 0.55(1-h)(80-58)$$
$$79 = 80 - 0.55(1-h)(22)$$
$$79 = 80 - 12.1(1-h)$$
$$79 = 80 - 12.1 + 12.1h$$
$$79 = 67.9 + 12.1h$$
$$12.1h = 11.1$$
$$h = \frac{11.1}{12.1} =$$
$$h = 0.9173553719 \approx 0.92$$

A relative humidity of 92% gives an index of 79.

43. $M = 0.959W - 1.226$

$$50,560 = 0.959W - 1.226$$
$$0.959W = 50,561.226$$
$$W = \frac{50,561.226}{0.959} \approx 52,723$$

The median annual salary for whites is approximately $57,723.

44. Let $B(t)$ = 14.44, and calculate t.

$$14.44 = 3.303t - 6591.56$$
$$14.44 + 6591.56 = 3.303t$$
$$6606 = 3.303t$$
$$t = \frac{6606}{3.303}$$
$$t = 2000$$

The model predicts that in 2000 there will be 14.44 million accounts.

45. Recall that $5F - 9C = 160$. Let $F = C$, and solve for C.

$$5C - 9C = 160$$
$$-4C = 160$$
$$C = \frac{160}{-4}$$
$$C = -40$$

Therefore, $F = C$ when the temperature is -40°.

46. Let $y = 80$, and solve for x.

$$80 = 1.78x - 3.998$$
$$1.78x = 83.998$$
$$x = \frac{83.998}{1.78} \approx 47.19$$

Based on the model, the level will reach 80% in approximately 1997.

47. Let $y = 259.4$, and solve for x.

$$259.4 = 0.155x + 255.37$$
$$259.4 - 255.37 = 0.155x$$
$$4.03 = 0.155x$$
$$x = \frac{4.03}{0.155}$$
$$x = 26$$

An x-value of 26 corresponds to the year 1996. The average reading score is 259.4 in 1996.

48. Let $B(t) = 47.88$, and calculate t.

$$47.88 = 20.37 + 1.834t$$
$$1.834t = 27.51$$
$$t = \frac{27.51}{1.834} = 15$$

In 1995 the per capita tax burden is $4788.

49. Let $B(x) = 35.32$, and calculate x.

$$35.32 = -3.963x + 51.172$$
$$-3.963x = -15.852$$
$$x = \frac{-15.852}{-3.963} = 4$$

Based on the model, the average monthly mobile phone bill is $35.32 in 1999.

50. $y = -0.0762x + 8.5284$

$$6.09 = -0.0762x + 8.5284$$
$$-0.0762x = -2.4384$$
$$x = \frac{-2.4384}{-0.0762} = 32$$

When x is 32, the year is 1982.

The model predicts the marriage rate to be 6.09% in 1982.

51. Note that p is in thousands. A population of 258,241,000 corresponds to a p-value of 258,241. Let $p = 258{,}241$ and solve for x.

$$258{,}241 = 2351x + 201{,}817$$
$$258{,}241 - 201{,}817 = 2351x$$
$$83{,}424 = 2351x$$
$$x = \frac{56{,}424}{2351}$$
$$x = 24$$

An x-value of 24 corresponds to the year 1994. Based on the model, in 1994 the population is estimated to be 258,241,000.

52. Let $P(x) = 44\%$, and solve for x.

$$44 = 26.5x - 62$$
$$44 + 62 = 26.5x$$
$$106 = 26.5x$$
$$x = \frac{106}{26.5} = 4$$

An x-value of 4 corresponds to the year 1999. Based on the model, forty-four percent of firms recruited on the Internet in 1999.

53. When the number of prisoners is 797,130, then $y = 797.130$. Let $y = 797.130$, and calculate x.

$$797.130 = 68.476x + 728.654$$
$$797.130 - 728.654 = 68.476x$$
$$68.476 = 68.476x$$
$$x = \frac{68.476}{68.476} = 1$$

An x-value of one corresponds to the year 1991. The number of inmates was 797,130 in 1991.

54. Let $p = 3.2\%$, and solve for x.

$$30(3.2) - 19x = 1$$
$$96 - 19x = 1$$
$$-19x = -95$$
$$x = \frac{-95}{-19} = 5$$

When x is 5, the year is 1995. During 1995 the percentage using marijuana daily was 3.2%

55. **a.** Let $p = 49\%$, and solve for x.

$$49 = 65.4042 - 0.3552x$$
$$49 - 65.4042 = -0.3552x$$
$$-61.4042 = -0.3552x$$
$$x = \frac{-16.4042}{-0.3552}$$
$$x \approx 46.2$$

An x-value of 46 corresponds to the year 1996. The model predicts that in 1996 the percent voting in a presidential election is 49%

b. Year 2000 corresponds with an x-value of 50. Let $x = 50$, and solve for p.

$$p = 65.4042 - 0.3552(50)$$
$$p = 65.4042 - 17.76$$
$$p = 47.6442$$

Based on the model the percentage of people voting in the 2000 election was approximately 47.6%. The prediction is different from reality. Models do not always yield accurate predictions.

56. Let $I(x) = 7190$, and solve for x.

$$7190 = 341.28x + 4459.78$$
$$7190 - 4459.78 = 341.28x$$
$$2730.22 = 341.28x$$
$$x = \frac{2730.22}{341.28}$$
$$x = 7.99 \approx 8$$

An x-value of 8 corresponds to the year 1998. Based on the model, U.S. personal income reached $7190 billion in 1998.

57. Let $y = 6000$, and solve for x.

$$6000 = 277.318x - 1424.766$$
$$277.318x = 7424.766$$
$$x = \frac{7424.766}{277.318} \approx 26.77$$

An x-value of 27 corresponds to the year 1997. Cigarette advertising exceeds $6 billion in 1997.

58. If the number of customers is 68,200,000, then the value of $S(x)$ is 68.2. Let $S(x) = 68.2$, and solve for x.

$68.2 = 11.75x + 32.95$

$68.2 - 32.95 = 11.75x$

$35.25 = 11.75x$

$x = \frac{35.25}{11.75} = 3$

An x-value of 3 corresponds to the year 1998. There were 68.2 million subscribers in 1998.

59. Let x represent the score on the fifth exam.

$90 = \frac{92 + 86 + 79 + 96 + x}{5}$

LCM: 5

$5(90) = 5\left(\frac{92 + 86 + 79 + 96 + x}{5}\right)$

$450 = 353 + x$

$x = 97$

The student must score 97 on the fifth exam to earn a 90 in the course.

60. Since the final exam score must be higher than 79 to earn a 90 average, the 79 will be dropped from computation. Therefore, if the final exam scores is x, the student's average is $\frac{2x + 86 + 96}{4}$.

To determine the final exam score that produces a 90 average, let

$\frac{2x + 86 + 96}{4} = 90.$

$LCM : 4$

$4\left(\frac{2x + 86 + 96}{4}\right) = 4(90)$

$2x + 86 + 96 = 360$

$2x + 182 = 360$

$2x = 178$

$x = \frac{178}{2} = 89$

The student must score at least an 89 on the final exam.

61. Let x = the company's 1999 revenue in billions of dollars.

$0.94x = 74$

$x = \frac{74}{0.94}$

$x \approx 78.723$

The company's 1999 revenue was approximately $78.723 billion.

62. Let x = the company's 1999 revenue in billions of dollars.

$4.79x = 36$

$x = \frac{36}{4.79}$

$x \approx 7.52$

The company's 1999 revenue was approximately $7.52 billion.

63. Commission Reduction

$= (20\%)(50,000)$

$= 10,000$

New Commission

$= 50,000 - 10,000$

$= 40,000$

To return to a $50,000 commission, the commission must be increased $10,000. The percentage increase is now based on the $40,000 commission. L

Let x represent the percent increase from the second year.

$40,000x = 10,000$

$x = 0.25 = 25\%$

64. Salary Reduction

$=(5\%)(100,000)$

$=5000$

New Salary

$=100,000-5000$

$=95,000$

To return increase to a $104,500 salary, the new $95,000 must be increased $9,500. The percentage increase is now based on the $95,000 salary.

Let x represent the percent raise from the reduced salary.

$$95,000x=9500$$

$$x=\frac{9500}{95,000}=0.10=10\%$$

65. Total cost = Original price + Sales tax

Let $x=$ original price.

$$29,998=x+6\%x$$

$$29,998=x+0.06x$$

$$29,998=1.06x$$

$$x=\frac{29,998}{1.06}=28,300$$

Sales tax = $29,998-28,300=\$1698$

66. Let x = total in population.

$$\frac{x}{50}=\frac{50}{20}$$

$$1000\left(\frac{x}{50}\right)=1000\left(\frac{50}{20}\right)$$

$$20x=2500$$

$$x=\frac{2500}{20}=125$$

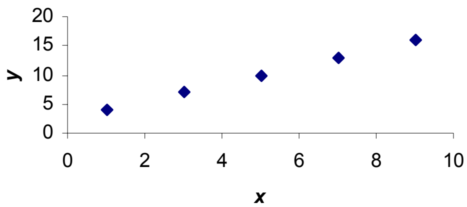
The estimated population is 125 sharks.

Section 1.6 Skills Check

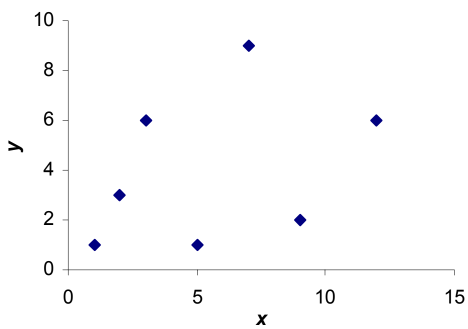
1. No. The data points do not lie approximately in a straight line.

2. Yes. The data points lie approximately in a straight line.

3.



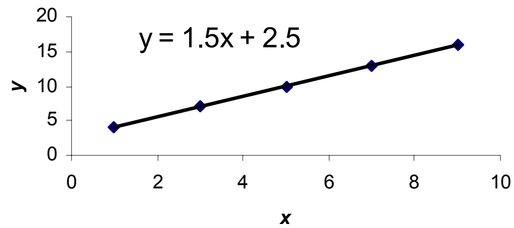
4.



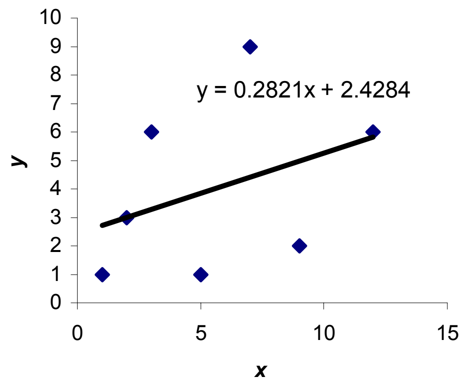
5. Exactly. The first differences are constantly three.

6. No. The first differences are not constant. Also, a line will not connect perfectly the points on the scatter plot.

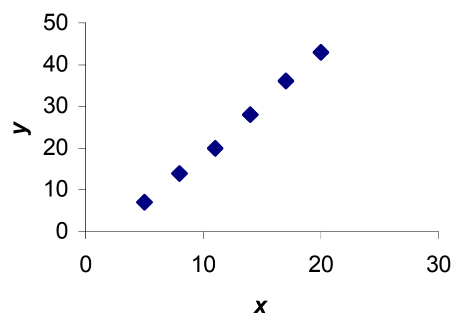
7. Using a spreadsheet program yields



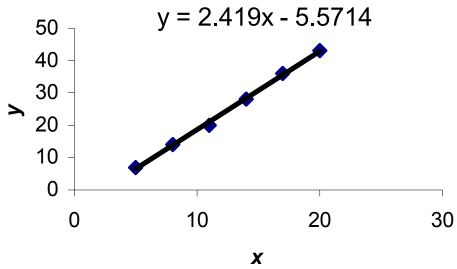
8. Using a spreadsheet program yields



9.



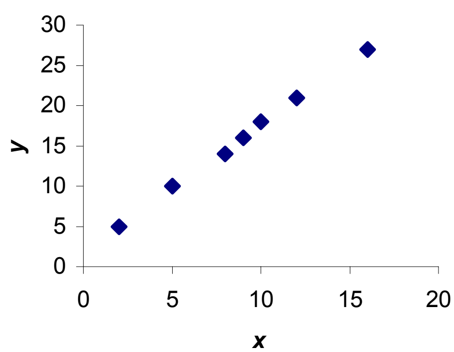
10. Yes. The points appear to lie approximately along a line. Using a spreadsheet program yields



11. See problem 10 above. $y = 2.419x - 5.571$

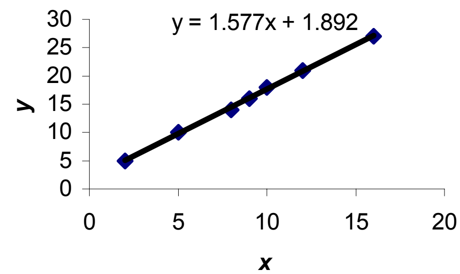
12.
$$\begin{aligned} f(3) &= 2.419(3) - 5.5714 \\ &= 7.257 - 5.5714 \\ &= 1.6856 \approx 1.7 \\ f(5) &= 2.419(5) - 5.5714 \\ &= 12.095 - 5.5714 \\ &= 6.5236 \approx 6.5 \end{aligned}$$

13.



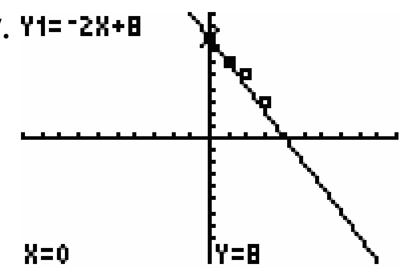
14. Yes. The points appear to lie approximately along a line.

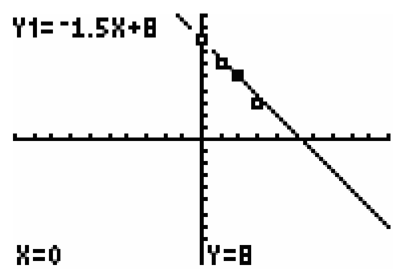
15. Using a spreadsheet program yields



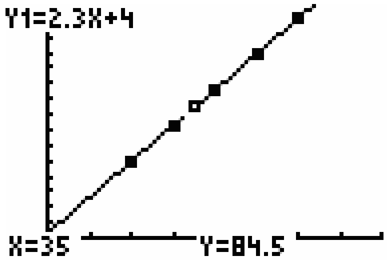
16.
$$\begin{aligned} f(3) &= 1.577(3)+1.892 \\ &= 4.731+1.892 \\ &= 6.623 \approx 6.6 \\ f(5) &= 1.577(5)+1.892 \\ &= 7.885 + 1.892 \\ &= 9.777 \approx 9.8 \end{aligned}$$

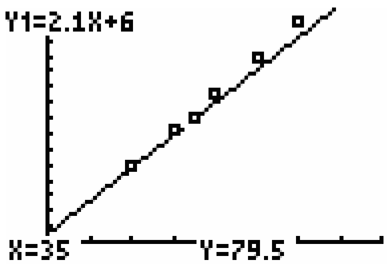
17.





The second equation, $y = -1.5x + 8$, is a better fit to the data points.

18. 



The first equation, $y = 2.3x + 4$, is a better fit to the data points.

19. a. Exactly linear. The first differences are constant

b. Nonlinear. The first differences increase continuously.

c. Approximately linear. The first differences vary, but don't grow continuously.

20. The difference between inputs is not constant. The inputs are not equally spaced.

Section 1.6 Exercises

21. a. Discrete. The ratio is calculated each year, and the years are one unit apart.

b. No. A line would not fit the points on the scatter plot.

c. Yes. Beginning in 2010, a line would fit the points on the scatter plot well.

22. a. Discrete. There are gaps between the years.

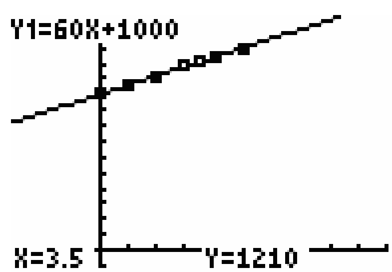
b. Continuous. Gaps between the years no longer exist.

c. No. A line would not fit the points on the scatter plot. A non-linear function is best.

23. a. Yes. There is a one unit gap between the years and a constant 60 unit gap in future values.

b. Yes. Since the first differences are constant, the future value can be modeled by a linear function

c. Using the graphing calculator yields



[–3, 10] by [–100, 1500]

24. $p(5.75)$ does not make sense, since 5.75 does not correspond exactly to a specific month.

25. a. Let $x = 23$. Then,

$$y = 15.910x + 242.758$$
$$= 15.910(23) + 242.758$$
$$= 365.93 + 242.758$$
$$= 608.688$$

Based on the model, 608,688 people were employed in dentist's offices in 1993. Since 1993 is within the range of the data used to generate the model (1970-1998), this calculation is an interpolation.

b. Let $x = 30$. Then,

$$y = 15.910x + 242.758$$
$$= 15.910(30) + 242.758$$
$$= 477.3 + 242.758$$
$$= 720.058$$

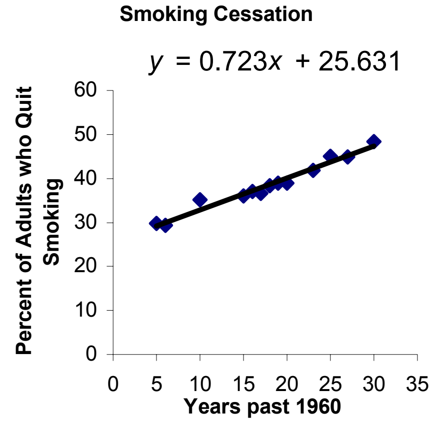
Based on the model, 720,058 people were employed in dentist's offices in 2000. Since 2000 is not within the range of the data used to generate the model (1970-1998), this calculation is an extrapolation.

26. a. Since x represents years past 1990, the model is discrete.

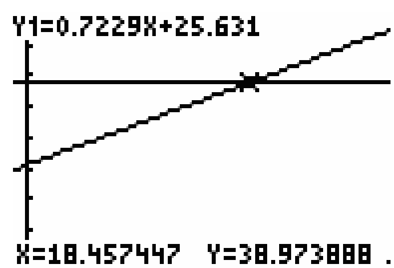
b. Yes, since 9 corresponds exactly to a specific year. $P(9)$ represents the percentage of Fortune Global 500 firms that actively recruit workers in 1999.

c. No. $P(9.4)$ is not valid, since 9.4 does not correspond exactly to a specific year.

27. a. Using a spreadsheet program yields



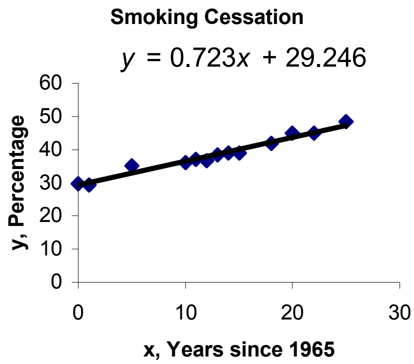
b. Solve $0.723x + 25.631 = 39$. Using the intersections of graphs method to determine x when $y = 39$ yields



Based on the model, 39% of adults had quit smoking 18.46 years past 1960. Therefore, the year was approximately 1978.

c. Since the data is not exactly linear (see the scatter plot in part a) above), the model will yield only approximate solutions.

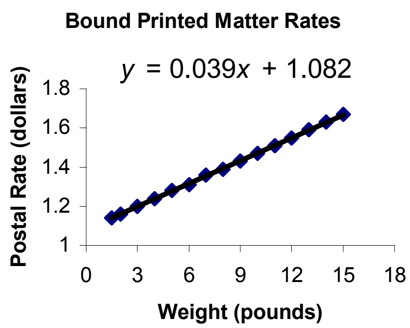
28. a. Using a spreadsheet program yields



b. See part a) above.

c. The slope is the same, but y-intercept is different.

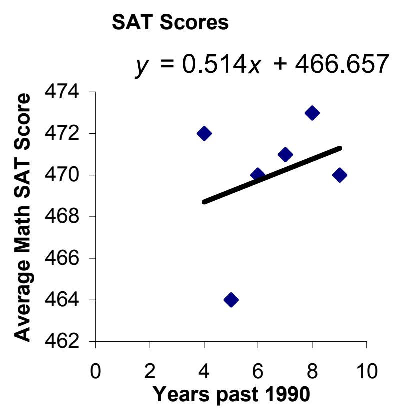
29. a. Using a spreadsheet program yields



b. The model fits the data very well. Notice the small residuals in the following table.

Weight (pounds)	Actual postal rate (dollars)	Predicted postal rate based on the regression equation (dollars)	Residual (difference between the actual and predicted values) (dollars)
2	1.16	1.159675	0.000325
3	1.20	1.198734	0.001266
4	1.24	1.237794	0.002206
5	1.28	1.276853	0.003147
6	1.31	1.315913	–0.005913
7	1.36	1.354972	0.005028
8	1.39	1.394031	–0.004031
9	1.43	1.433091	–0.003091
10	1.47	1.472150	–0.002150
11	1.51	1.511210	–0.001210
12	1.55	1.550269	–0.000269
13	1.59	1.589328	0.000672
14	1.63	1.628388	0.001612
15	1.67	1.667447	0.002553

30. Using a spreadsheet program yields



Year	Actual data	Model prediction	Difference
1994	472	468.7172	–3.2828
1995	464	469.2315	5.2315
1996	470	469.7458	–0.2542
1997	471	470.2601	–0.7399
1998	473	470.7744	–2.2256
1999	470	471.2887	1.2887

The actual and predicted values are closest in 1996.

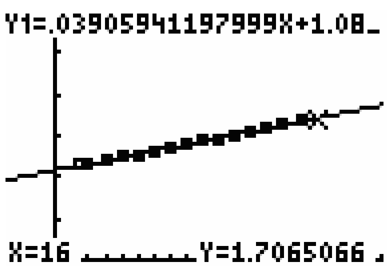
31. a. Let $x=16,$ and solve for y.

$y=0.039(16)+1.082$

$y=0.624+1.082$

$y=1.706\approx 1.71$

Using the unrounded model yields



[–3, 20] by [0, 3]

b. Let $y=1.55,$ and solve for x.

$1.55=0.039x+1.082$

$1.55-1.082=0.039x$

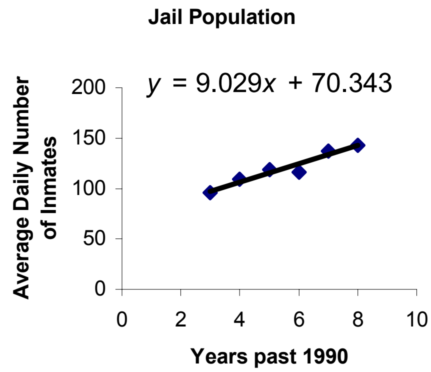
$0.039x=0.468$

$x=\dfrac{0.468}{0.039}=12$ pounds

c. The slope of the linear model is 0.039. Therefore, for when the weight changes by one pound, the postal rate changes by approximately 3.9 cents.

d. Considering the data, the change in postal rate between 9 pounds and 14 pounds is 4 cents per pound.

32. a. Using a spreadsheet program yields



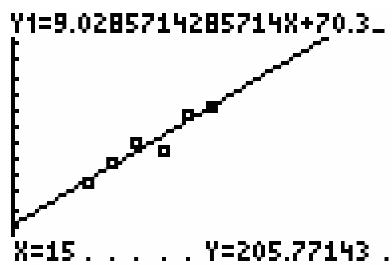
b. Let $x=2005-1990=15,$ and solve for y.

$y=9.029(15)+70.343$

$y=205.778\approx 206$

In 2005 the model predicts an average daily prison population of 206.

Using the unrounded model yields



[0, 15] by [50, 200]

c. Let $y=116,$ and solve for x.

$116=9.029x+70.343$

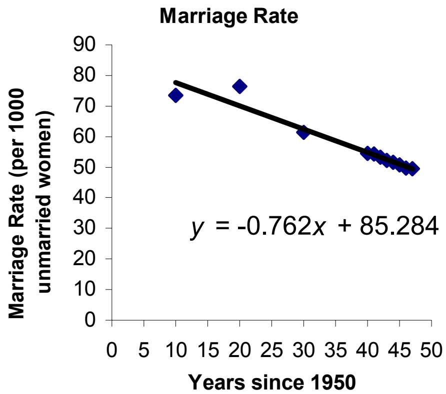
$116-70.343=9.0286x$

$9.029x=45.657$

$x=\dfrac{45.657}{9.029}\approx 5.057$

The model predicts that in 1995 the average daily prison population is 116.

33. a. Using a spreadsheet program yields



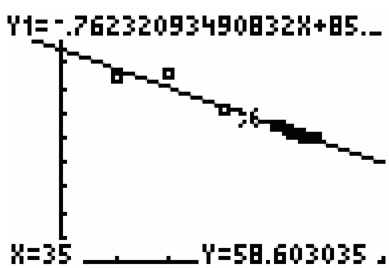
b. Let $x = 1985 - 1950 = 35,$ and solve for y.

$y = -0.7622(35) + 85.284$

$y = 58.607 \approx 58.6$

The model predicts 58.6 marriages per 1000 unmarried women.

Using the unrounded model yields



[–10, 60] by [0, 100]

c. Let $y = 50,$ and solve for x.

$50 = -0.762x + 85.284$

$50 - 85.284 = -0.762x$

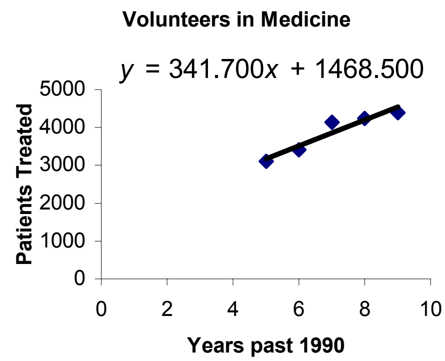
$-0.762x = -35.284$

$x = \dfrac{-35.284}{-0.762} = 46.304 \approx 46.3$

50 marriages per 1000 unmarried women occurs in approximately 1996.

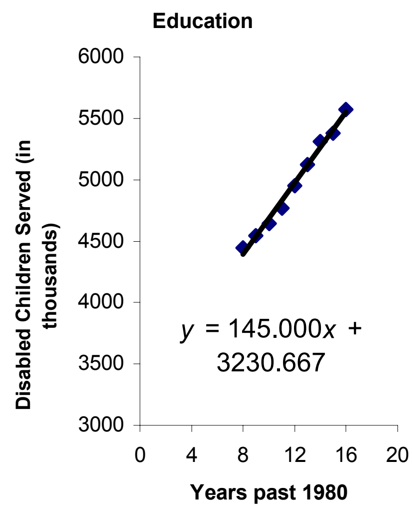
d. The answer in part c) is an approximation based on the model. Considering the data, the marriage rate is 50 between 1995 and 1996.

34. a. Using a spreadsheet program yields



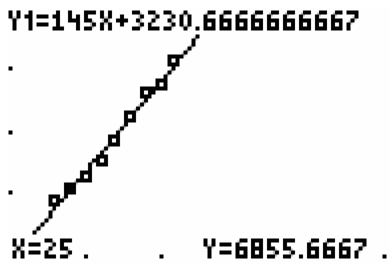
b. Based on the slope of model, each year the number of patients treated increases by approximately 342.

35. a. Using a spreadsheet program yields



b. Based on the model, when the time increases by one year, the number of disabled children served increases by 145,000.

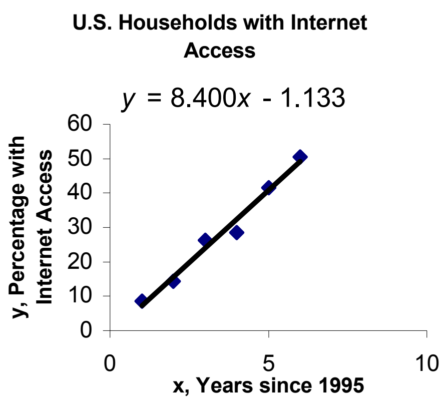
c. In 2005, $x = 25$. Using the unrounded model yields



[5, 30] by [4000, 6000]

Approximately 6,856,000 children will be served in 2005 based on the model. This is an extrapolation, since 2005 is beyond the scope of the available data.

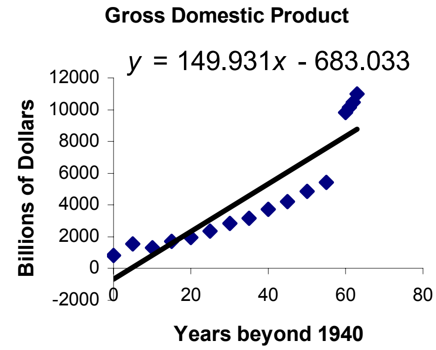
36. a. Using a spreadsheet program yields



b. See 37 a) above. The equation is $y = 8.400x - 1.133$.

c. See 37 a) above. The model fits the data set reasonably well.

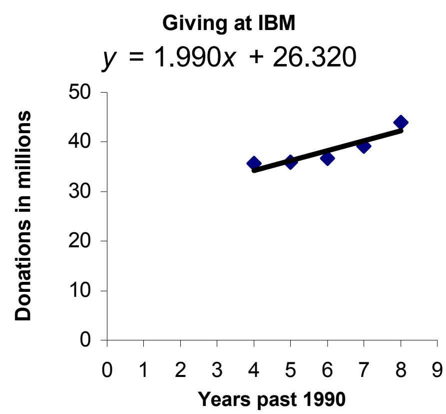
37. a. Using a spreadsheet program yields



b. See 37 a) above. The equation is $y = 149.931x - 683.003$.

c. Considering the scatter plot, the model does not fit the data very well.

38. a. Using a spreadsheet program yields

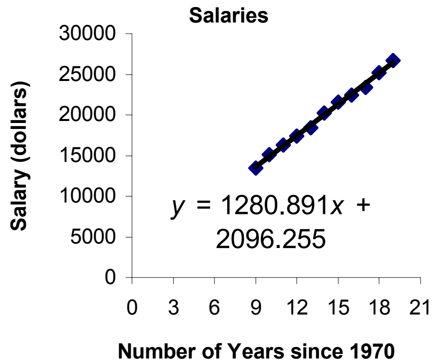


b. Let $y = 50$, and solve for x.

$$50 = 1.990x + 26.320$$
$$50 - 26.320 = 1.990x$$
$$1.990x = 23.680$$
$$x = \frac{23.680}{1.990} = 11.89949749 \approx 11.9$$

Donations reach \$50 million in 2002.

39. a. Using a spreadsheet program yields

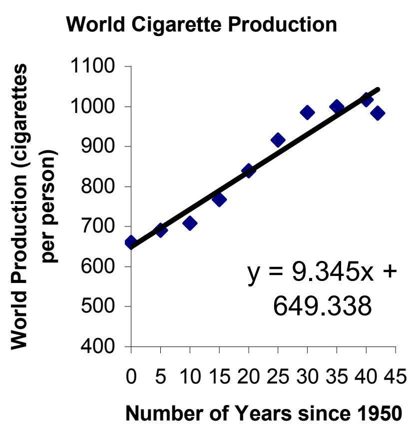


b. See 39 a) above. The equation is $y = 1280.891x + 2096.255$.

c. See 39 a) above. The linear function fits the data points very well. The line is very close to the data points on the scatter plot.

d. **i.** Discrete
ii. Discrete
iii. Continuous. The model is not limited to data from the table.

40. a. Using a spreadsheet program yields



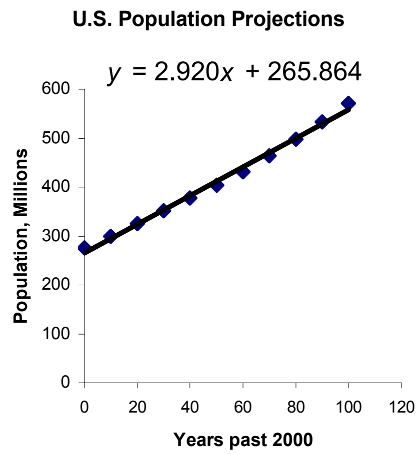
The equation is $y = 9.345x + 649.338$.

b. Continuous. The model is not restricted to values of x from the table of given values.

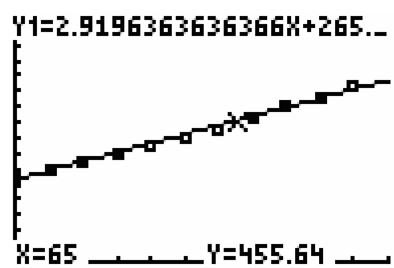
c. On a per person basis, cigarette production increased until 1990. Then it began to decrease.

d. No. If the decreasing trend that began in 1990 continues, the linear model calculated in part a) will not be valid between 1993 and 2003.

41. a. Using a spreadsheet program yields



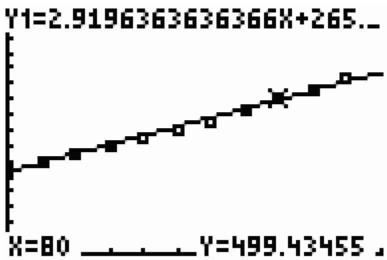
b. Using the unrounded model, $f(65) \approx 455.64$.



[0, 100] by [0, 800]

In 2065, the projected U.S. population is 455.64 million or 455,640,000.

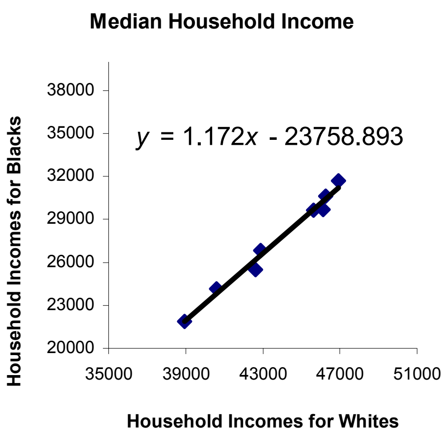
c. In 2080, $x = 80$.



[0, 100] by [0, 800]

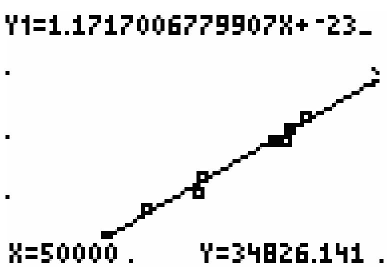
Based on the model, the U.S. population in 2080 will be 499.4 million. The prediction in the table is slightly smaller, 497.8 million.

42. a. Using a spreadsheet program yields



b. See 42 a) above. The model is $y = 1.172x - 23{,}758.893$

c. Let $x = 50{,}000$. Using the unrounded model yields $y = 34{,}826.14$.



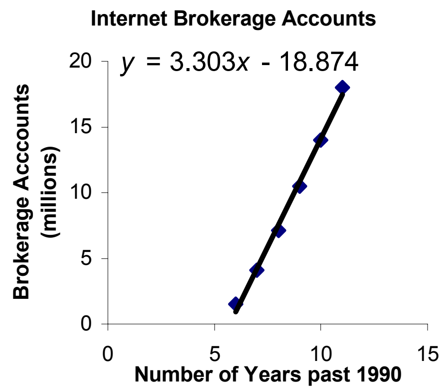
[35,000, 50,000] by [20,000] by [40,000]

When median household income for whites is $50,000, median household income for blacks is $34,826.41.

Using the rounded model yields:

$$y = 1.172(50{,}000) - 23{,}758.893$$
$$y = 34{,}841.11$$

43. a. Using a spreadsheet program yields



b. Considering the slope of the linear model, a one year increase in time corresponds to a 3.3 million unit increase in Internet brokerage accounts.

c. Let $y = 20$, and solve for x.

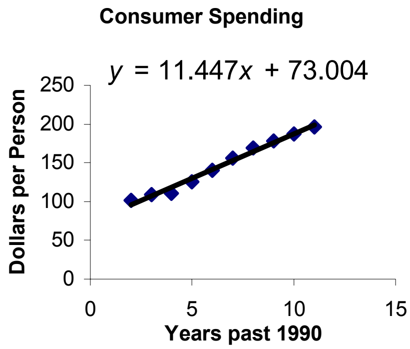
$$20 = 3.303x - 18.874$$
$$20 + 18.874 = 3.303x$$
$$38.874 = 3.303x$$
$$x = \frac{38.874}{3.303} = 11.7693 \approx 11.8$$

19.

Based on the model, the number of Internet brokerage accounts will be 20 million near the end of 2001.

d. The model may no longer be valid due to economic and social instability resulting from the terrorist attacks on September 11, 2001.

44. a. Using a spreadsheet program yields



b. Let $y = 250$, and solve for x.

$250 = 11.447x + 73.004$

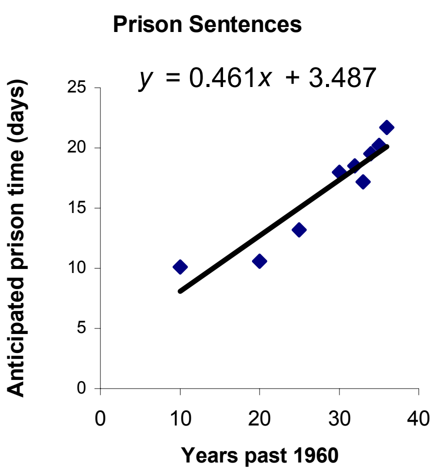
$11.447x = 176.004$

$x = \frac{176.004}{11.447} = 15.4622 \approx 15.5$

Per capita spending for television services first exceeds \$250 during 2005.

c. Since the calculation in part b) yields an answer beyond the scope of the original data, an assumption must be made that the model remains valid for years beyond 2001. The calculation in part b) is an extrapolation.

45. a. Using a spreadsheet program yields



b. Let $x = 15$, and solve for y.

$y = 0.461(15) + 3.487$

$y = 10.402$

Based on the model the anticipated prison time in 1975 is approximately 10.4 days.

Section 1.7 Skills Check

1. Applying the substitution method

$y = 3x - 2$ and $y = 3 - 2x$

$3 - 2x = 3x - 2$

$3 - 2x - 3x = 3x - 3x - 2$

$3 - 5x = -2$

$-5x = -5$

$x = 1$

Substituting to find y

$y = 3(1) - 2 = 1$

$(1,1)$ is the intersection point.

2. Applying the elimination method

$$\begin{cases} 3x + 2y = 5 & (Eq\,1) \\ 5x - 3y = 21 & (Eq\,2) \end{cases}$$

$$\begin{cases} 9x + 6y = 15 & 3 \times (Eq\,1) \\ 10x - 6y = 42 & 2 \times (Eq\,2) \end{cases}$$

$19x = 57$

$x = \frac{57}{19} = 3$

Substituting to find y

$3(3) + 2y = 5$

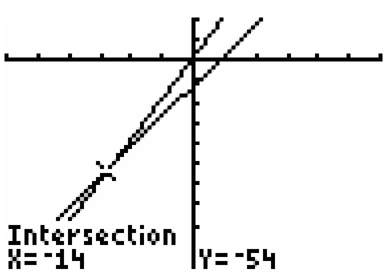
$9 + 2y = 5$

$2y = -4$

$y = -2$

$(3,-2)$ is the intersection point.

3. Applying the intersection of graphs method



[–30, 30] by [–100, 20]

The solution is $(-14,-54)$.

4. Solving the equations for y

$2x - 4y = 6$

$-4y = -2x + 6$

$y = \frac{-2x + 6}{-4}$

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

and

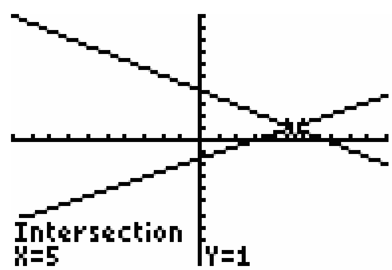
$3x + 5y = 20$

$5y = -3x + 20$

$y = \frac{-3x + 20}{5}$

$y = -\frac{3}{5}x + 4$

Applying the intersection of graphs method



[–10, 10] by [–10, 10]

The solution is $(5,1)$.

5. Solving the equations for y

$4x-3y=-4$

$-3y=-4x-4$

$y=\dfrac{-4x-4}{-3}$

$y=\dfrac{4}{3}x+\dfrac{4}{3}$

and

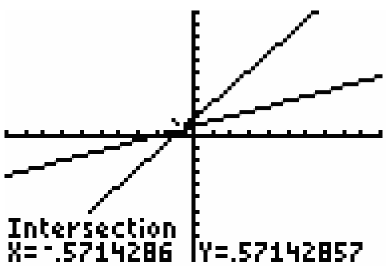
$2x-5y=-4$

$-5y=-2x-4$

$y=\dfrac{-2x-4}{-5}$

$y=\dfrac{2}{5}x+\dfrac{4}{5}$

Applying the intersection of graphs method



[–10, 10] by [–10, 10]

The solution is $(-0.5714, 0.5714)$ or $\left(-\dfrac{4}{7}, \dfrac{4}{7}\right)$.

6. Solving the equations for y

$5x-6y=22$

$-6y=-5x+22$

$y=\dfrac{-5x+22}{-6}$

$y=\dfrac{5}{6}x-\dfrac{11}{3}$

and

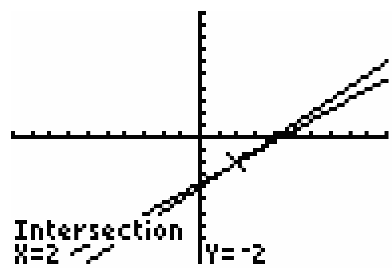
$4x-4y=16$

$-4y=-4x+16$

$y=\dfrac{-4x+16}{-4}$

$y=x-4$

Applying the intersection of graphs method



[–10, 10] by [–10, 10]

The solution is $(2,-2)$.

7. $\begin{cases} 2x+5y=6 & (Eq\,1) \\ x+2.5y=3 & (Eq\,2) \end{cases}$

$\begin{cases} 2x+5y=6 & (Eq\,1) \\ -2x-5y=-6 & -2\times(Eq\,2) \end{cases}$

$0=0$

There are infinitely many solutions to the system. The graphs of both equations represent the same line.

8. $\begin{cases} 6x+4y=3 & (Eq\,1) \\ 3x+2y=3 & (Eq\,2) \end{cases}$

$\begin{cases} 6x+4y=3 & (Eq\,1) \\ -6x-4y=-6 & -2\times(Eq\,2) \end{cases}$

$0=-3$

There is no solution to the system. The graphs of the equations represent parallel lines.

9. $\begin{cases} x-5y=12 \\ 3x+4y=-2 \end{cases}$

Solving the first equation for x

$x-5y=12$

$x=5y+12$

Substituting into the second equation

$3(5y+12)+4y=-2$

$15y+36+4y=-2$

$19y+36=-2$

$19y=-38$

$y=-2$

Substituting to find x

$x-5(-2)=12$

$x+10=12$

$x=2$

The solution is $(2,-2)$.

10. $\begin{cases} 2x-3y=2 \\ 5x-y=18 \end{cases}$

Solving the second equation for y

$5x-y=18$

$-y=-5x+18$

$y=5x-18$

Substituting into the first equation

$2x-3(5x-18)=2$

$2x-15x+54=2$

$-13x+54=2$

$-13x=-52$

$x=4$

Substituting to find y

$2(4)-3y=2$

$8-3y=2$

$-3y=-6$

$y=2$

The solution is $(4,2)$.

11. $\begin{cases} 2x-3y=5 \\ 5x+4y=1 \end{cases}$

Solving the first equation for x

$2x-3y=5$

$2x=3y+5$

$x=\dfrac{3y+5}{2}$

Substituting into the second equation

$5\left(\dfrac{3y+5}{2}\right)+4y=1$

$2\left[5\left(\dfrac{3y+5}{2}\right)+4y\right]=2[1]$

$15y+25+8y=2$

$23y+25=2$

$23y=-23$

$y=-1$

Substituting to find x

$2x-3(-1)=5$

$2x+3=5$

$2x=2$

$x=1$

The solution is $(1,-1)$.

12. $\begin{cases} 4x-5y=-17 \\ 3x+2y=-7 \end{cases}$

Solving the first equation for x

$4x-5y=-17$

$4x=5y-17$

$x=\dfrac{5y-17}{4}$

Substituting into the second equation

$3\left(\dfrac{5y-17}{4}\right)+2y=-7$

$4\left[3\left(\dfrac{5y-17}{4}\right)+2y\right]=4[-7]$

$15y-51+8y=-28$

$23y-51=-28$

$23y=23$

$y=1$

Substituting to find x

$4x-5(1)=-17$

$4x-5=-17$

$4x=-12$

$x=-3$

The solution is $(-3,1)$.

13. $\begin{cases} x+3y=5 & (Eq1) \\ 2x+4y=8 & (Eq2) \end{cases}$

$\begin{cases} -2x-6y=-10 & -2\times(Eq1) \\ 2x+4y=8 & (Eq2) \end{cases}$

$-2y=-2$

$y=1$

Substituting to find x

$x+3(1)=5$

$x+3=5$

$x=2$

The solution is $(2,1)$.

14. $\begin{cases} 4x - 3y = -13 & (Eq1) \\ 5x + 6y = 13 & (Eq2) \end{cases}$

$\begin{cases} 8x - 6y = -26 & 2 \times (Eq1) \\ 5x + 6y = 13 & (Eq2) \end{cases}$

$13x = -13$

$x = -1$

Substituting to find x

$4(-1) - 3y = -13$

$-4 - 3y = -13$

$-3y = -9$

$y = 3$

The solution is $(-1, 3)$.

15. $\begin{cases} 5x + 3y = 8 & (Eq1) \\ 2x + 4y = 8 & (Eq2) \end{cases}$

$\begin{cases} -10x - 6y = -16 & -2 \times (Eq1) \\ 10x + 20y = 40 & 5 \times (Eq2) \end{cases}$

$14y = 24$

$y = \frac{24}{14} = \frac{12}{7}$

Substituting to find x

$2x + 4\left(\frac{12}{7}\right) = 8$

$7\left[2x + \left(\frac{48}{7}\right)\right] = 7[8]$

$14x + 48 = 56$

$14x = 8$

$x = \frac{8}{14} = \frac{4}{7}$

The solution is $\left(\frac{4}{7}, \frac{12}{7}\right)$.

16. $\begin{cases} 3x + 3y = 5 & (Eq1) \\ 2x + 4y = 8 & (Eq2) \end{cases}$

$\begin{cases} -12x - 12y = -20 & -4 \times (Eq1) \\ 6x + 12y = 24 & 3 \times (Eq2) \end{cases}$

$-6x = 4$

$y = \frac{4}{-6} = -\frac{2}{3}$

Substituting to find x

$3\left(-\frac{2}{3}\right) + 3y = 5$

$-2 + 3y = 5$

$3y = 7$

$y = \frac{7}{3}$

The solution is $\left(-\frac{2}{3}, \frac{7}{3}\right)$.

17. $\begin{cases} 0.3x + 0.4y = 2.4 & (Eq1) \\ 5x - 3y = 11 & (Eq2) \end{cases}$

$\begin{cases} 9x + 12y = 72 & 30 \times (Eq1) \\ 20x - 12y = 44 & 4 \times (Eq2) \end{cases}$

$29x = 116$

$x = \frac{116}{29} = 4$

Substituting to find x

$5(4) - 3y = 11$

$20 - 3y = 11$

$-3y = -9$

$y = 3$

The solution is $(4, 3)$.

18. $\begin{cases} 8x-4y=0 & (Eq1) \\ 0.5x+0.3y=2.2 & (Eq2) \end{cases}$

$\begin{cases} 24x-12y=0 & 3\times(Eq1) \\ 20x-12y=88 & 40\times(Eq2) \end{cases}$

$44x=88$

$x=2$

Substituting to find x

$8(2)-4y=0$

$16-4y=0$

$4y=16$

$y=4$

The solution is $(2,4)$.

19. $\begin{cases} 3x+6y=12 & (Eq1) \\ 2x+4y=8 & (Eq2) \end{cases}$

$\begin{cases} -6x-12y=-24 & -2\times(Eq1) \\ 6x+12y=24 & 3\times(Eq2) \end{cases}$

$0=0$

Infinitely many solutions. The lines are the same. This is a dependent system.

20. $\begin{cases} -4x+6y=12 & (Eq1) \\ 10x-15y=-30 & (Eq2) \end{cases}$

$\begin{cases} -20x+30y=60 & 5\times(Eq1) \\ 20x-30y=-60 & 2\times(Eq2) \end{cases}$

$0=0$

Infinitely many solutions. The lines are the same. This is a dependent system.

21. $\begin{cases} 6x-9y=12 & (Eq1) \\ 3x-4.5y=-6 & (Eq2) \end{cases}$

$\begin{cases} 6x-9y=12 & (Eq1) \\ -6x+9y=12 & -2\times(Eq2) \end{cases}$

$0=24$

No solution. Lines are parallel.

22. $\begin{cases} 4x-8y=5 & (Eq1) \\ 6x-12y=10 & (Eq2) \end{cases}$

$\begin{cases} 12x-24y=15 & 3\times(Eq1) \\ -12x+24y=-20 & -2\times(Eq2) \end{cases}$

$0=-5$

No solution. Lines are parallel.

23. $\begin{cases} y=3x-2 \\ y=5x-6 \end{cases}$

Substituting the first equation into the second equation

$3x-2=5x-6$

$-2x-2=-6$

$-2x=-4$

$x=2$

Substituting to find y

$y=3(2)-2=6-2=4$

The solution is $(2,4)$.

24. $\begin{cases} y=8x-6 \\ y=14x-12 \end{cases}$

Substituting the first equation into the second equation

$8x-6=14x-12$

$-6x=-6$

$x=1$

Substituting to find y

$y=14(1)-12$

$y=2$

The solution is $(1,2)$.

25. $\begin{cases} 4x+6y=4 \\ x=4y+8 \end{cases}$

Substituting the second equationinto the first equation

$4(4y+8)+6y=4$

$16y+32+6y=4$

$22y+32=4$

$22y=-28$

$y=\frac{-28}{22}=-\frac{14}{11}$

Substituting to find x

$x=4\left(-\frac{14}{11}\right)+8$

$x=-\frac{56}{11}+\frac{88}{11}=\frac{32}{11}$

The solution is $\left(\frac{32}{11},-\frac{14}{11}\right)$.

26. $\begin{cases} y=4x-5 \\ 3x-4y=7 \end{cases}$

Substituting the first equation into the second equation

$3x-4(4x-5)=7$

$3x-16x+20=7$

$-13x=-13$

$x=1$

Substituting to find y

$y=4(1)-5$

$y=-1$

The solution is $(1,-1)$.

27. $\begin{cases} 2x-5y=16 & (Eq1) \\ 6x-8y=34 & (Eq2) \end{cases}$

$\begin{cases} -6x+15y=-48 & -3\times(Eq1) \\ 6x-8y=34 & (Eq2) \end{cases}$

$7y=-14$

$y=-2$

Substituting to find x

$2x-5(-2)=16$

$2x+10=16$

$2x=6$

$x=3$

The solution is $(3,-2)$.

28. $\begin{cases} 4x-y=4 & (Eq1) \\ 6x+3y=15 & (Eq2) \end{cases}$

$\begin{cases} 12x-3y=12 & 3\times(Eq1) \\ 6x+3y=15 & (Eq2) \end{cases}$

$18x=27$

$x=\frac{27}{18}=\frac{3}{2}$

Substituting to find y

$4\left(\frac{3}{2}\right)-y=4$

$6-y=4$

$-y=-2$

$y=2$

The solution is $\left(\frac{3}{2},2\right)$.

29. $\begin{cases} 3x - 7y = -1 & (Eq1) \\ 4x + 3y = 11 & (Eq2) \end{cases}$

$\begin{cases} -12x + 28y = 4 & -4 \times (Eq1) \\ 12x + 9y = 33 & 3 \times (Eq2) \end{cases}$

$37y = 37$

$y = \frac{37}{37} = 1$

Substituting to find x

$3x - 7(1) = -1$

$3x - 7 = -1$

$3x = 6$

$x = 2$

The solution is $(2,1)$.

30. $\begin{cases} 5x - 3y = 12 & (Eq1) \\ 3x - 5y = 8 & (Eq2) \end{cases}$

$\begin{cases} -15x + 9y = -36 & -3 \times (Eq1) \\ 15x - 25y = 40 & 5 \times (Eq2) \end{cases}$

$-16y = 4$

$y = \frac{4}{-16} = -\frac{1}{4}$

Substituting to find x

$5x - 3\left(-\frac{1}{4}\right) = 12$

$5x + \frac{3}{4} = 12$

$4\left(5x + \frac{3}{4}\right) = 4(12)$

$20x + 3 = 48$

$20x = 45$

$x = \frac{45}{20} = \frac{9}{4}$

The solution is $\left(\frac{9}{4}, -\frac{1}{4}\right)$.

31. $\begin{cases} 4x - 3y = 9 & (Eq1) \\ 8x - 6y = 16 & (Eq2) \end{cases}$

$\begin{cases} -8x + 6y = -18 & -2 \times (Eq1) \\ 8x - 6y = 16 & (Eq2) \end{cases}$

$0 = -2$

No solution. Lines are parallel.

32. $\begin{cases} 5x - 4y = 8 & (Eq1) \\ -15x + 12y = -12 & (Eq2) \end{cases}$

$\begin{cases} 15x - 12y = 24 & 3 \times (Eq1) \\ -15x + 12y = -12 & (Eq2) \end{cases}$

$0 = 12$

No solution. Lines are parallel.

Section 1.7 Exercises

33. $R = C$

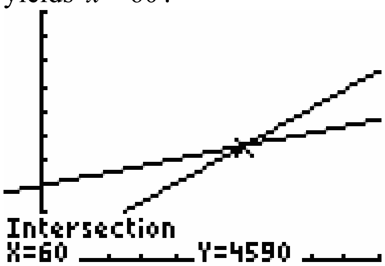
$76.50x = 2970 + 27x$

$49.50x = 2970$

$x = \dfrac{2970}{49.50}$

$x = 60$

Applying the intersections of graphs method yields $x = 60$.



[–10, 100] by [–10, 10,000]

Break-even occurs when the number of units produced and sold is 60.

34. $R = C$

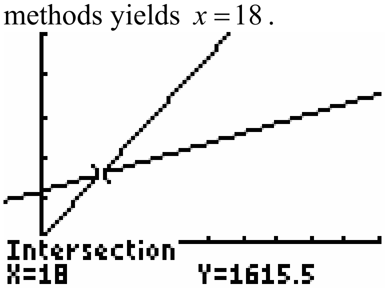
$89.75x = 23.50x + 1192.50$

$66.25x = 1192.50$

$x = \dfrac{1192.50}{66.25}$

$x = 18$

Applying the intersections of graphs methods yields $x = 18$.



[–10, 100] by [–1000, 5000]

Break-even occurs when the number of units produced and sold is 18.

35. a. Let $p = 60$ and solve for q.

Supply function

$60 = 5q + 20$

$5q = 40$

$q = 8$

Demand function

$60 = 128 - 4q$

$-4q = -68$

$q = \dfrac{-68}{-4} = 17$

When the price is \$60, the quantity supplied is 8, while the quantity demanded is 17.

b. Equilibrium occurs when the demand equals the supply,

$5q + 20 = 128 - 4q$

$9q + 20 = 128$

$9q = 108$

$q = \dfrac{108}{9} = 12$

Substituting to calculate p

$p = 5(12) + 20 = 80$

When the price is \$80, 12 units are produced and sold. This level of production and price represents equilibrium.

36. $\begin{cases} p+2q=320 & (Eq1) \\ p-8q=20 & (Eq2) \end{cases}$

$\begin{cases} 4p+8q=1280 & 4\times(Eq1) \\ p-8q=20 & (Eq2) \end{cases}$

$5p=1300$

$p=\frac{1300}{5}=260$

Substituting to find q

$260-8q=20$

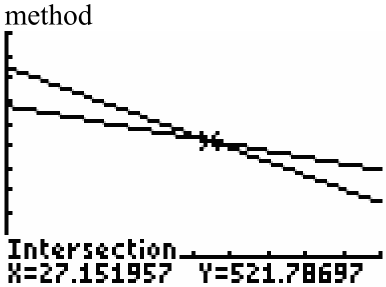
$-8q=-240$

$q=\frac{-240}{-8}=30$

The solution is $(260,30)$.

Equilibrium occurs when 30 units are demanded and supplied at a price of $260 per unit.

37. a. Applying the intersection of graphs method

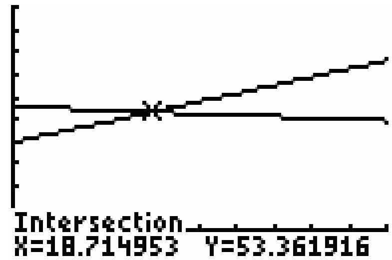


[0, 50] by [–100, 1000]

The solution is $(27.152, 521.787)$. The number of active duty Navy personnel equals the number of active duty Air Force personnel in 1987.

b. Considering the solution in part *a*, approximately 521,787 people will be on active duty in each service branch.

38. Applying the intersection of graphs method



[0, 50] by [–10, 100]

The solution is $(18.715, 53.362)$. The percentage of male students enrolled in college within 12 months of high school graduation equals the percentage of female students enrolled in college within 12 months of high school graduation in 1979.

39. a. $\begin{cases} y=24.5x+93.5 \\ y=-0.2x+1007 \end{cases}$

Substituting the first equation into the second equation

$24.5x+93.5=-0.2x+1007$

$10(24.5x+93.5)=10(-0.2x+1007)$

$245x+935=-2x+10,070$

$247x+935=10,070$

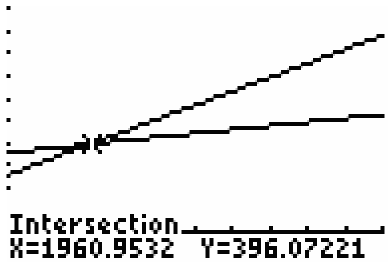
$247x=9135$

$x=\frac{9135}{247}=36.9838\approx 37$

b. In $1990+37=2027$, mint sales and gum sales are equal.

c. The graphs are misleading. Notice that the scales are different. Mint sales are measured between $0 and $300 million, while gum sales are measured between $0 and $1000 million. Also note that the first tick mark on the *y*-axis for each graph represents inconsistent units when compared with the remainder of the graph.

40. Applying the intersection of graphs method



[1950, 2000] by [–100, 1000]

The solution is $(1960.95, 396.07)$. The number of nursing homes in Massachusetts equals the number of nursing homes in Illinois at the end of 1960 or approximately 1961. The number of nursing homes in each state is approximately 396.

41. Let l = the low stock price, and let h = the high stock price.

$$\begin{cases} h + l = 83.5 & (Eq1) \\ h - l = 21.88 & (Eq2) \end{cases}$$

$2h = 105.38$

$h = \frac{105.38}{2} = 52.69$

Substituting to calculate l

$52.69 + l = 83.5$

$l = 30.81$

The high stock price is \$52.69, while the low stock price is \$30.81.

42. Let l = the 1998 revenue, and let h = the 1999 revenue.

$$\begin{cases} h + 2l = 2144.9 & (Eq1) \\ h - l = 135.5 & (Eq2) \end{cases}$$

$$\begin{cases} h + 2l = 2144.9 & (Eq1) \\ 2h - 2l = 271 & 2 \times (Eq2) \end{cases}$$

$3h = 2415.9$

$h = \frac{2415.9}{3} = 805.3$

Substituting to calculate l

$805.3 - l = 135.5$

$-l = -669.8$

$l = 669.8$

The 1998 revenue is \$669.8 million, while the 1999 revenue is \$805.3 million.

43. **a.** $x + y = 2400$

b. $30x$

c. $45y$

d. $30x + 45y = 84{,}000$

e. $$\begin{cases} x + y = 2400 & (Eq1) \\ 30x + 45y = 84{,}000 & (Eq2) \end{cases}$$

$$\begin{cases} -30x - 30y = -72{,}000 & -30 \times (Eq1) \\ 30x + 45y = 84{,}000 & (Eq2) \end{cases}$$

$15y = 12{,}000$

$y = \frac{12{,}000}{15} = 800$

Substituting to calculate x

$x + 800 = 2400$

$x = 1600$

The promoter needs to sell 1600 tickets at \$30 per ticket and 800 tickets at \$45 per ticket.

44. **a.** $x + y = 250{,}000$

b. $10\%x$ or $0.10x$

c. $12\%y$ or $0.12y$

d. $0.10x + 0.12y = 26{,}500$

e. $\begin{cases} x + y = 250{,}000 & (Eq1) \\ 0.10x + 0.12y = 26{,}500 & (Eq2) \end{cases}$

$\begin{cases} -0.10x - 0.10y = -25{,}000 & -0.10 \times (Eq1) \\ 0.10x + 0.12y = 26{,}500 & (Eq2) \end{cases}$

$0.02y = 1500$

$y = \dfrac{1500}{0.02} = 75{,}000$

Substituting to calculate x

$x + 75{,}000 = 250{,}000$

$x = 175{,}000$

$175,000 is invested in the 10% property, and $75,000 is invested in the 12% property.

45. **a.** Let x = the amount in the safer account, and let y = the amount in the riskier account.

$\begin{cases} x + y = 100{,}000 & (Eq1) \\ 0.08x + 0.12y = 9000 & (Eq2) \end{cases}$

$\begin{cases} -0.08x - 0.08y = -8000 & -0.08 \times (Eq1) \\ 0.08x + 0.12y = 9000 & (Eq2) \end{cases}$

$0.04y = 1000$

$y = \dfrac{1000}{0.04} = 25{,}000$

Substituting to calculate x

$x + 25{,}000 = 100{,}000$

$x = 75{,}000$

$75,000 is invested in the 8% account, and $25,000 is invested in the 12% account.

b. Using two accounts minimizes investment risk.

46. Let x = the amount in the safer fund, and let y = the amount in the riskier fund.

$$\begin{cases} x + y = 52{,}000 & (Eq1) \\ 0.10x + 0.14y = 5720 & (Eq2) \end{cases}$$

$$\begin{cases} -0.10x - 0.10y = -5200 & -0.10 \times (Eq1) \\ 0.10x + 0.14y = 5720 & (Eq2) \end{cases}$$

$0.04y = 520$

$y = \dfrac{520}{0.04} = 13{,}000$

Substituting to calculate x

$x + 13{,}000 = 52{,}000$

$x = 39{,}000$

\$39,000 is invested in the 10% fund, and \$13,000 is invested in the 14% fund.

47. Let x = the number of glasses of milk, and let y = the number of quarter pound servings of meat.

Protein equation:

$8.5x + 22y = 69.5$

Iron equation:

$0.1x + 3.4y = 7.1$

$$\begin{cases} 8.5x + 22y = 69.5 & (Eq1) \\ 0.1x + 3.4y = 7.1 & (Eq2) \end{cases}$$

$$\begin{cases} 8.5x + 22y = 69.5 & (Eq1) \\ -8.5x - 289y = -603.5 & -85 \times (Eq2) \end{cases}$$

$-267y = -534$

$y = \dfrac{-534}{-267} = 2$

Substituting to calculate x

$8.5x + 22(2) = 69.5$

$8.5x + 44 = 69.5$

$8.5x = 25.5$

$x = \dfrac{25.5}{8.5} = 3$

The person on the special diet needs to consume 3 glasses of milk and 2 quarter pound portions of meat to reach the required iron and protein content in the diet.

48. Let x = the amount of substance A, and let y = the amount of substance B.

Nutrient equation:

$6\%x + 10\%y = 100\%$

$$\begin{cases} x + y = 14 & (Eq1) \\ 0.06x + 0.10y = 1 & (Eq2) \end{cases}$$

$$\begin{cases} -0.06x - 0.06y = -0.84 & -0.06 \times (Eq1) \\ 0.06x + 0.10y = 1 & (Eq2) \end{cases}$$

$0.04y = 0.16$

$y = \dfrac{0.16}{0.04} = 4$

Substituting to calculate x

$x + 4 = 14$

$x = 10$

The patient needs to consume 10 ounces of substance A and 4 ounces of substance B to reach the required nutrient level of 100%.

49. Let x = the amount of 10% solution, and let y = the amount of 5% solution.

$x + y = 20$

Medicine concentration:

$10\%x + 5\%y = 8\%(20)$

$$\begin{cases} x + y = 20 & (Eq1) \\ 0.10x + 0.05y = 1.6 & (Eq2) \end{cases}$$

$$\begin{cases} -0.10x - 0.10y = -2 & -0.10 \times (Eq1) \\ 0.10x + 0.05y = 1.6 & (Eq2) \end{cases}$$

$-0.05y = -0.4$

$y = \dfrac{-0.4}{-0.05} = 8$

Substituting to calculate x

$x + 8 = 20$

$x = 12$

The nurse needs to mix 12 cc of the 10% solution with 8 cc of the 5% solution to obtain 20 cc of an 8% solution.

50. Let x = the amount of the 30% solution, and let y = the amount of the 15% solution.

$x + y = 45$

Medicine concentration:

$30\%x + 15\%y = 20\%(45)$

$$\begin{cases} x + y = 45 & (Eq1) \\ 0.30x + 0.15y = 9 & (Eq2) \end{cases}$$

$$\begin{cases} -0.30x - 0.30y = -13.5 & -0.30 \times (Eq1) \\ 0.30x + 0.15y = 9 & (Eq2) \end{cases}$$

$-0.15y = -4.5$

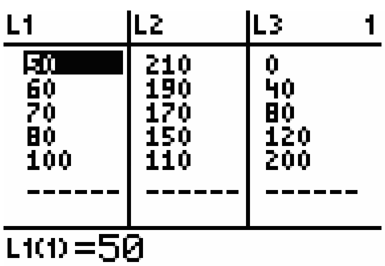
$y = \dfrac{-4.5}{-0.15} = 30$

Substituting to calculate x

$x + 30 = 45$

$x = 15$

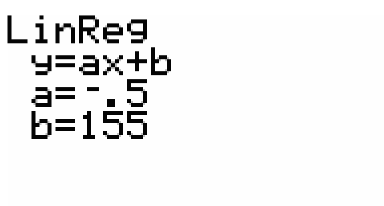
The nurse needs to mix 15 cc of the 30% solution with 30 cc of the 15% solution to obtain 45 cc of a 20% solution.

51. 

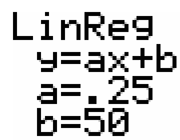
L1	L2	L3
50	210	0
60	190	40
70	170	80
80	150	120
100	110	200

L1(1)=50

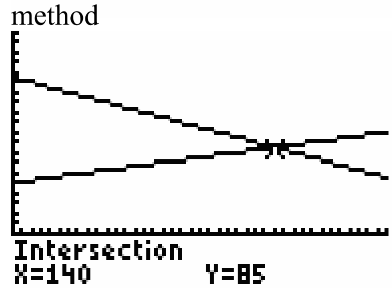
a. Demand function: Finding a linear model using L_2 as input and L_1 as output yields $p = -\frac{1}{2}q + 155$.



b. Supply function: Finding a linear model using L_3 as input and L_1 as output yields $p = \frac{1}{4}q + 50$.



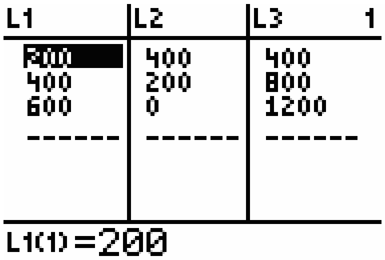
c. Applying the intersection of graphs method



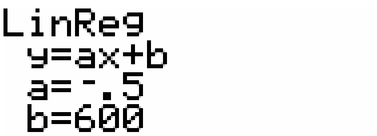
[0, 200] by [–50, 200]

When the price is \$85, 140 units are both supplied and demanded. Therefore, equilibrium occurs when the price is \$85 per unit.

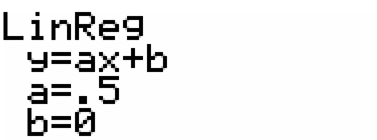
52.



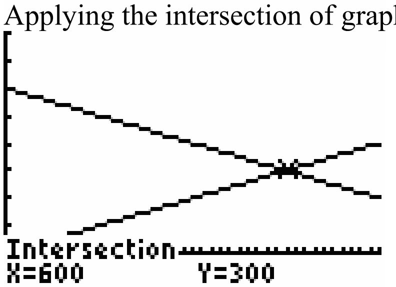
Demand function: Finding a linear model using L_3 as input and L_2 as output yields $p = -\frac{1}{2}q + 600$.



Supply function: Finding a linear model using L_3 as input and L_1 as output yields $p = \frac{1}{2}q + 0$ or $p = \frac{1}{2}q$.



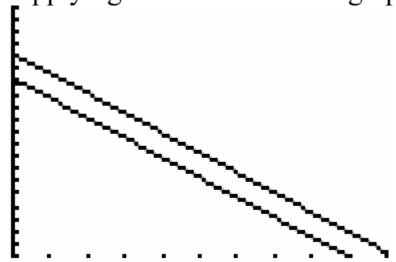
Applying the intersection of graphs method



[0, 800] by [–100, 800]

When the price is \$300, 600 units are both supplied and demanded. Therefore equilibrium occurs when the price is \$300 per unit

53. Applying the intersection of graphs method



[0, 10] by [55, 75]

Note that the lines do not intersect. The slopes are the same, but the y-intercepts are different. There is no solution to the system. Based on the two models, the percentages are never equal.

54. Let x = the amount of federal tax, and let y = the amount of Alabama tax.

a. The federal taxable income is $1,000,000 - y$.

$$x = (1,000,000 - y)(34\%)$$
$$x = 340,000 - 0.34y$$

b. Alabama taxable income is $1,000,000 - x$.

$$y = (1,000,000 - x)(5\%)$$
$$y = 50,000 - 0.05x$$

c. $$\begin{cases} x = 340,000 - 0.34y \\ y = 50,000 - 0.05x \end{cases}$$

d. $\begin{cases} x = 340,000 - 0.34y \\ y = 50,000 - 0.05x \end{cases}$

Substituting the second equation into the first equation yields:

$x = 340,000 - 0.34(50,000 - 0.05x)$

$x = 340,000 - 17,000 + 0.017x$

$x = 323,000 + 0.017x$

$0.983x = 323,000$

$x = \frac{323,000}{0.983} = 328,585.96$

Substituting to find y

$y = 50,000 - 0.05(328,585.96)$

$y = 33,570.70$

Federal income tax is $328,585.96, while Alabama income tax is $33,570.70.

55. a. $300x + 200y = 100,000$

b. $x = 2y$

$300(2y) + 200y = 100,000$

$800y = 100,000$

$y = \frac{100,000}{800} = 125$

Substituting to calculate x

$x = 2(125) = 250$

There are 250 clients in the first group and 125 clients in the second group.

56. $20\%x + 5\%y = 15.5\%(x + y)$

$0.20x + 0.05y = 0.155x + 0.155y$

$0.045x = 0.105y$

$\frac{0.045x}{0.105} = \frac{0.105y}{0.105}$

$y = \frac{3}{7}x$

Therefore, the amount of y must equal $\frac{3}{7}$ of the amount of x.

If $x = 7$, $y = \frac{3}{7}(7) = 3$.

The 5% concentration must be increased by 3 cc.

57. The slope of the demand function is

$m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{10 - 60}{900 - 400} = \frac{-50}{500} = \frac{-1}{10}.$

Calculating the equation:

$y - y_1 = m(x - x_1)$

$y - 10 = \frac{-1}{10}(x - 900)$

$y - 10 = \frac{-1}{10}x + 90$

$y = \frac{-1}{10}x + 100$ or

$p = \frac{-1}{10}q + 100$

Likewise, the slope of the supply function is

$m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{30 - 50}{700 - 1400} = \frac{-20}{-700} = \frac{2}{70}.$

Calculating the equation

$y - y_1 = m(x - x_1)$

$y - 30 = \frac{2}{70}(x - 700)$

$y - 30 = \frac{2}{70}x - 20$

$y = \frac{2}{70}x + 10$ or

$p = \frac{2}{70}q + 10$

The quantity, q, that produces market equilibrium is 700.

$\frac{-1}{10}q + 100 = \frac{2}{70}q + 10$

$70\left(\frac{-1}{10}q + 100\right) = 70\left(\frac{2}{70}q + 10\right)$

$-7q + 7000 = 2q + 700$

$-9q = -6300$

$q = \frac{-6300}{-9} = 700$

The price, p, at market equilibrium is \$30.

$p = \frac{2}{70}(700) + 10$

$p = 2(10) + 10$

$p = 30$

700 units priced at \$30 represents the market equilibrium.

58. The slope of the demand function is $m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{350 - 300}{800 - 1200} = \frac{50}{-400} = \frac{-1}{8}$.

Calculating the equation

$y - y_1 = m(x - x_1)$

$y - 350 = \frac{-1}{8}(x - 800)$

$y - 350 = \frac{-1}{8}x + 100$

$y = \frac{-1}{8}x + 450$ or

$p = \frac{-1}{8}q + 450$

Likewise, the slope of the supply function is $m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{280 - 385}{700 - 1400} = \frac{-105}{-700} = \frac{3}{20}$.

Calculating the equation

$y - y_1 = m(x - x_1)$

$y - 280 = \frac{3}{20}(x - 700)$

$y - 280 = \frac{3}{20}x - 105$

$y = \frac{3}{20}x + 175$ or

$p = \frac{3}{20}q + 175$

The quantity, q, that produces market equilibrium is 1000.

$\frac{-1}{8}q + 450 = \frac{3}{20}q + 175$

$\text{LCM}: 40$

$40\left(\frac{-1}{8}q + 450\right) = 40\left(\frac{3}{20}q + 175\right)$

$-5q + 18{,}000 = 6q + 7000$

$-11q = -11{,}000$

$q = \frac{-11{,}000}{-11} = 1000$

The price, p, at market equilibrium is \$325.

$p = \frac{3}{20}(1000) + 175$

$p = 3(50) + 175$

$p = 325$

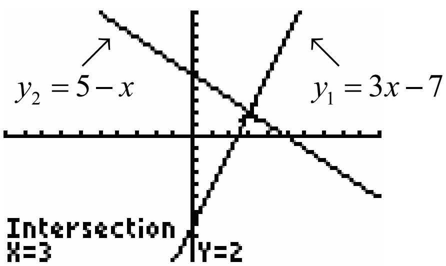
1000 units priced at \$325 each represents market equilibrium.

Section 1.8 Skills Check

1. Algebraically:

$$3x - 7 \le 5 - x$$
$$4x - 7 \le 5$$
$$4x \le 12$$
$$x \le \frac{12}{4}$$
$$x \le 3$$

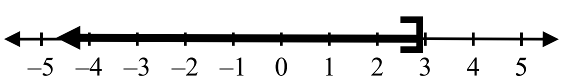
Graphically:



[–10, 10] by [–10, 10]

$3x - 7 \le 5 - x$ implies that the solution region is $x \le 3$.
The interval notation is $(-\infty, 3]$.

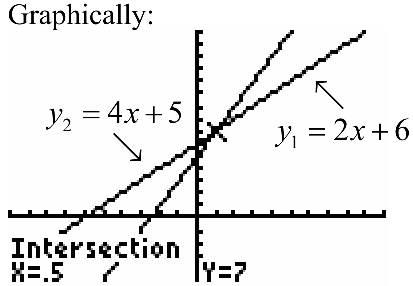
The graph of the solution is



2. Algebraically:

$$2x + 6 < 4x + 5$$
$$-2x + 6 < 5$$
$$-2x < -1$$
$$\frac{-2x}{-2} > \frac{-1}{-2} \quad \text{(Note the inequality sign switch)}$$
$$x > \frac{1}{2}$$

Graphically:

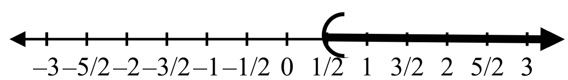


[–5, 5] by [–5, 15]

$2x + 6 < 4x + 5$ implies that the solution region is $x > \frac{1}{2}$.

The interval notation is $\left(\frac{1}{2}, \infty\right)$.

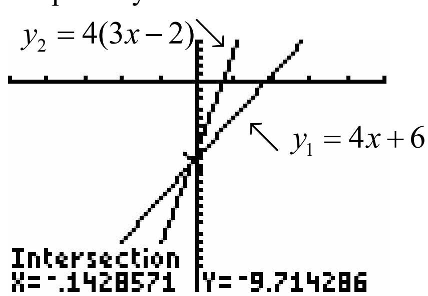
The graph of the solution is



3. Algebraically:

$$4(3x - 2) \le 5x - 9$$
$$12x - 8 \le 5x - 9$$
$$7x \le -1$$
$$\frac{7x}{7} \le \frac{-1}{7}$$
$$x \le -\frac{1}{7}$$

Graphically:

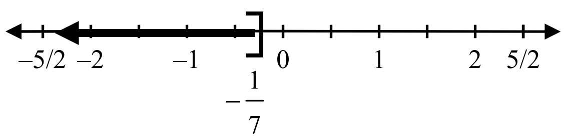


[–5, 5] by [–25, 5]

$4(3x-2) \le 5x-9$ implies that the solution region is $x \le -\frac{1}{7}$.

The interval notation is $\left(-\infty, -\frac{1}{7}\right]$.

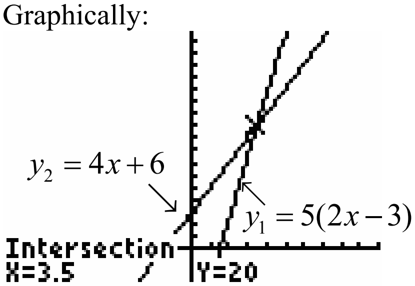
The graph of the solution is



4. Algebraically:

$$5(2x-3) > 4x+6$$
$$10x-15 > 4x+6$$
$$6x-15 > 6$$
$$6x > 21$$
$$x > \frac{21}{6}$$
$$x > \frac{7}{2}$$

Graphically:

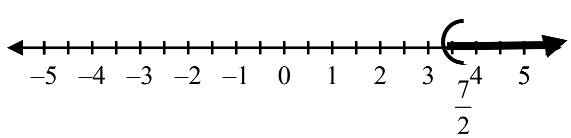


[–10, 10] by [–5, 35]

$5(2x-3)>4x+6$ implies that the solution region is $x > \frac{7}{2}$.

The interval notation is $\left(\frac{7}{2}, \infty\right)$.

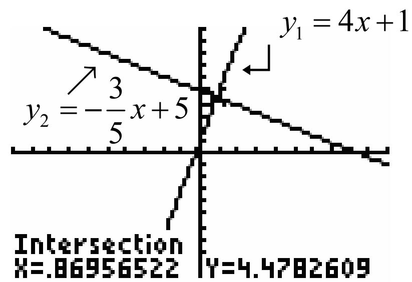
The graph of the solution is



5. Algebraically:

$$4x+1 < -\frac{3}{5}x+5$$
$$5(4x+1) < 5\left(-\frac{3}{5}x+5\right)$$
$$20x+5 < -3x+25$$
$$23x+5 < 25$$
$$23x < 20$$
$$x < \frac{20}{23}$$

Graphically:

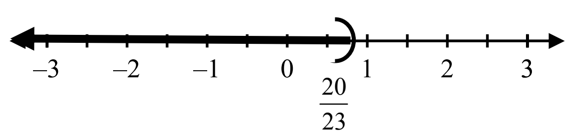


[–10, 10] by [–10, 10]

$4x+1 < -\frac{3}{5}x+5$ implies that the solution region is $x < \frac{20}{23}$.

The interval notation is $\left(-\infty, \frac{20}{23}\right)$.

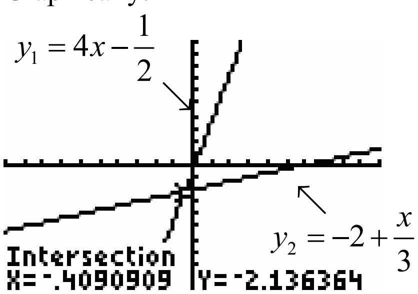
The graph of the solution is



6. Algebraically:

$$4x-\frac{1}{2}\le -2+\frac{x}{3}$$
$$6\left(4x-\frac{1}{2}\right)\le 6\left(-2+\frac{x}{3}\right)$$
$$24x-3\le -12+2x$$
$$22x-3\le -12$$
$$22x\le -9$$
$$x\le -\frac{9}{22}$$

Graphically:

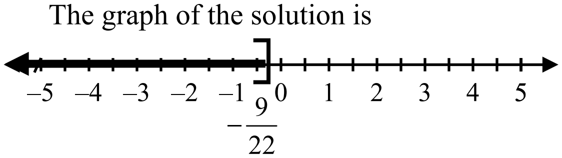


[–10, 10] by [–10, 10]

$4x-\frac{1}{2}\le -2+\frac{x}{3}$ implies that the solution region is $x\le -\frac{9}{22}$.

The interval notation is $\left(-\infty,-\frac{9}{22}\right]$.

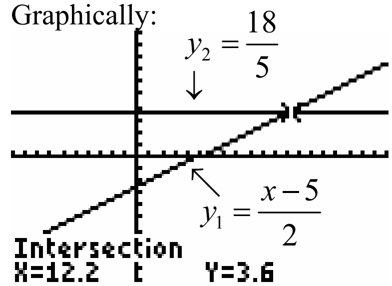
The graph of the solution is



7. Algebraically:

$$\frac{x-5}{2}<\frac{18}{5}$$
$$10\left(\frac{x-5}{2}\right)<10\left(\frac{18}{5}\right)$$
$$5(x-5)<2(18)$$
$$5x-25<36$$
$$5x<61$$
$$x<\frac{61}{5}$$

Graphically:

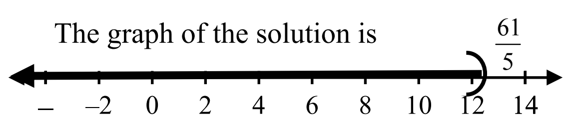


[–10, 20] by [–10, 10]

$\frac{x-5}{2}<\frac{18}{5}$ implies that the solution region is $x<\frac{61}{5}$.

The interval notation is $\left(-\infty,\frac{61}{5}\right)$.

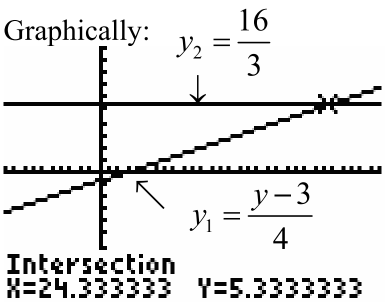
The graph of the solution is



8. Algebraically:

$$\frac{y-3}{4} < \frac{16}{3}$$
$$12\left(\frac{y-3}{4}\right) < 12\left(\frac{16}{3}\right)$$
$$3(y-3) < 64$$
$$3y-9 < 64$$
$$3y < 73$$
$$y < \frac{73}{3}$$

Graphically:

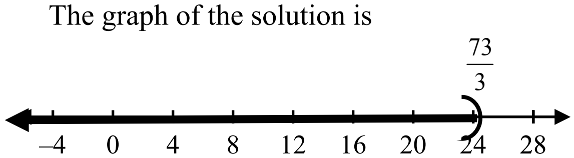


[–10, 30] by [–10, 10]

$\frac{y-3}{4} < \frac{16}{3}$ implies that the solution region is $x < \frac{73}{3}$.

The interval notation is $\left(-\infty, \frac{73}{3}\right)$.

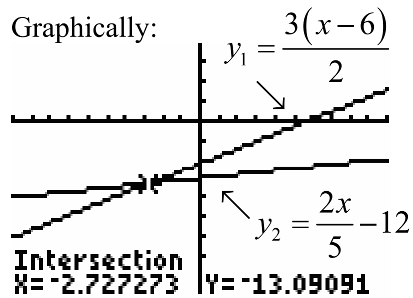
The graph of the solution is



9. Algebraically:

$$\frac{3(x-6)}{2} \geq \frac{2x}{5} - 12$$
$$10\left(\frac{3(x-6)}{2}\right) \geq 10\left(\frac{2x}{5} - 12\right)$$
$$5(3(x-6)) \geq 2(2x) - 120$$
$$15(x-6) \geq 4x - 120$$
$$15x - 90 \geq 4x - 120$$
$$11x - 90 \geq -120$$
$$11x \geq -30$$
$$x \geq -\frac{30}{11}$$

Graphically:

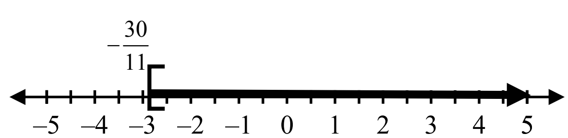


[–10, 10] by [–35, 15]

$\frac{3(x-6)}{2} \geq \frac{2x}{5} - 12$ implies that the solution region is $x \geq -\frac{30}{11}$.

The interval notation is $\left[-\frac{30}{11}, \infty\right)$.

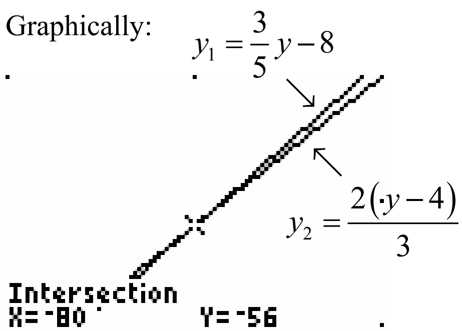
The graph of the solution is



10. Algebraically:

$$\frac{2(y-4)}{3} \ge \frac{3y}{5} - 8$$
$$15\left[\frac{2(y-4)}{3}\right] \ge 15\left[\frac{3y}{5} - 8\right]$$
$$10y - 40 \ge 9y - 120$$
$$y \ge -80$$

Graphically:

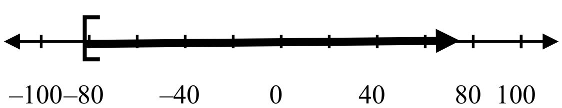


[–90, –70] by [–60, –50]

$\frac{2(y-4)}{3} \ge \frac{3y}{5} - 8$ implies that the solution region is $y \ge -80$.

The interval notation is $[-80, \infty)$.

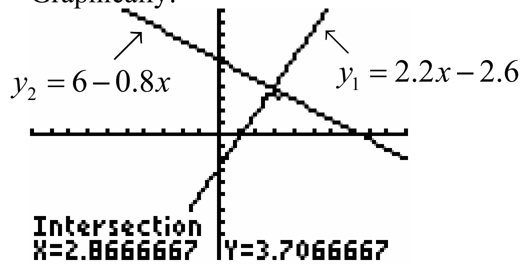
The graph of the solution is



11. Algebraically:

$$2.2x - 2.6 \ge 6 - 0.8x$$
$$3.0x - 2.6 \ge 6$$
$$3.0x \ge 8.6$$
$$x \ge \frac{8.6}{3.0}$$
$$x \ge 2.8\overline{6}$$

Graphically:

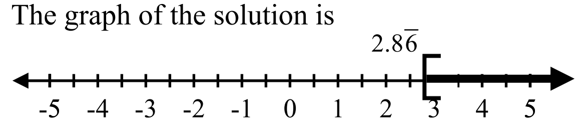


[–10, 10] by [–10, 10]

$2.2x - 2.6 \ge 6 - 0.8x$ implies that the solution region is $x \ge 2.8\overline{6}$.

The interval notation is $[2.8\overline{6}, \infty)$.

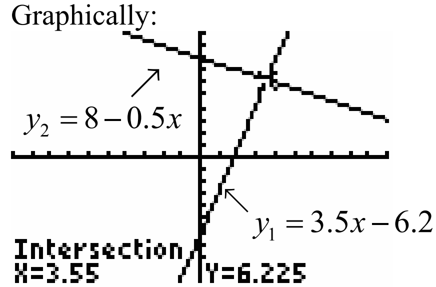
The graph of the solution is



12. Algebraically:

$$3.5x - 6.2 \le 8 - 0.5x$$
$$4x \le 14.2$$
$$x \le \frac{14.2}{4}$$
$$x \le 3.55$$

Graphically:

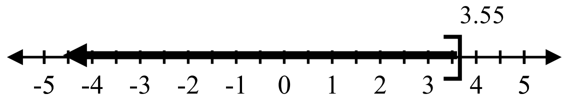


[–10, 10] by [–10, 10]

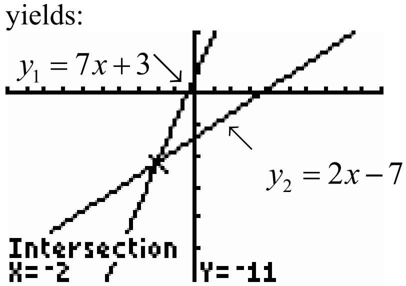
$3.5x - 6.2 \le 8 - 0.5x$ implies that the solution region is $x \le 3.55$.

The interval notation is $(-\infty, 3.55]$.

The graph of the solution is



13. Applying the intersection of graphs method yields:

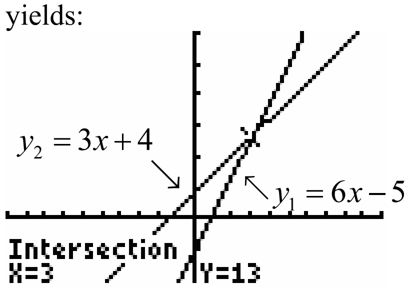


[–10, 10] by [–30, 10]

$7x + 3 < 2x - 7$ implies that the solution region is $x < -2$.

The interval notation is $(-\infty, -2)$.

14. Applying the intersection of graphs method yields:



[–10, 10] by [–10, 30]

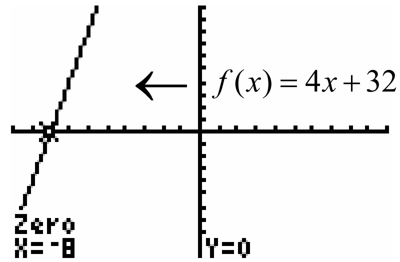
$3x + 4 \le 6x - 5$ implies that the solution region is $x < -2$.

The interval notation is $[3, \infty)$.

15. To apply the x-intercept method, first rewrite the inequality so that zero is on one side of the inequality.

$$5(2x + 4) \ge 6(x - 2)$$
$$10x + 20 \ge 6x - 12$$
$$4x + 32 \ge 0$$

Let $f(x) = 4x + 32$, and determine graphically where $f(x) \ge 0$.



[–10, 10] by [–10, 10]

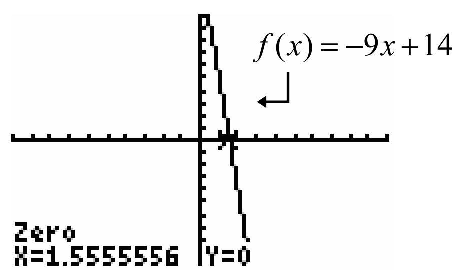
$f(x) \ge 0$ implies that the solution region is $x \ge -8$.

The interval notation is $[-8, \infty)$.

16. To apply the x-intercept method, first rewrite the inequality so that zero is on one side of the inequality.

$$-3(x - 4) \ge 2(3x - 1)$$
$$-3x + 12 \ge 6x - 2$$
$$-9x + 14 \ge 0$$

Let $f(x) = -9x + 14$, and determine graphically where $f(x) \ge 0$.



[–10, 10] by [–10, 10]

$f(x) \ge 0$ implies that the solution region is $x \le 1.\overline{5}$.

The interval notation is $(-\infty, 1.\overline{5}]$.

17. **a.** The x-coordinate of the intersection point is the solution. $x = -1$.

b. $(-\infty, -1)$

18. **a.** $x = 10$

b. $(-\infty, 30]$

c. No solution. $f(x)$ is never less than $h(x)$.

19.
$$17 \le 3x - 5 < 31$$
$$17 + 5 \le 3x - 5 + 5 < 31 + 5$$
$$22 \le 3x < 36$$
$$\frac{22}{3} \le \frac{3x}{3} < \frac{36}{3}$$
$$\frac{22}{3} \le x < 12$$
The interval notation is $\left[\frac{22}{3}, 12\right)$.

20.
$$120 < 20x - 40 \le 160$$
$$120 + 40 < 20x - 40 + 40 \le 160 + 40$$
$$160 < 20x \le 200$$
$$8 < x \le 10$$
The interval notation is $(8, 10]$.

21. $2x + 1 \ge 6$ and $2x + 1 \le 21$
$$6 \le 2x + 1 \le 21$$
$$5 \le 2x \le 20$$
$$\frac{5}{2} \le x \le 10$$
$x \ge \frac{5}{2}$ and $x \le 10$

The interval notation is $\left[\frac{5}{2}, 10\right]$.

22. $16x - 8 > 12$ and $16x - 8 < 32$
$$12 < 16x - 8 < 32$$
$$20 < 16x < 40$$
$$\frac{20}{16} < \frac{16x}{16} < \frac{40}{16}$$
$$\frac{5}{4} < x < \frac{5}{2}$$
$x > \frac{5}{4}$ and $x < \frac{5}{2}$

The interval notation is $\left(\frac{5}{4}, \frac{5}{2}\right)$.

23. $3x + 1 < -7$ and $2x - 5 > 6$

Inequality 1

$3x + 1 < -7$

$3x < -8$

$x < -\frac{8}{3}$

Inequality 2

$2x - 5 > 6$

$2x > 11$

$x > \frac{11}{2}$

$x < -\frac{8}{3}$ and $x > \frac{11}{2}$

24. $6x - 2 \le -5$ or $3x + 4 > 9$

Inequality 1

$6x - 2 \le -5$

$6x \le -3$

$x \le -\frac{1}{2}$

Inequality 2

$3x + 4 > 9$

$3x > 5$

$x > \frac{5}{3}$

$x \le -\frac{1}{2}$ or $x > \frac{5}{3}$

25. $\frac{3}{4}x-2\geq 6-2x$ or $\frac{2}{3}x-1\geq 2x-2$

Inequality 1

$$4\left(\frac{3}{4}x-2\right)\geq 4(6-2x)$$
$$3x-8\geq 24-8x$$
$$11x\geq 32$$
$$x\geq \frac{32}{11}$$

Inequality 2

$$3\left(\frac{2}{3}x-1\right)\geq 3(2x-2)$$
$$2x-3\geq 6x-6$$
$$-4x\geq -3$$
$$x\leq \frac{3}{4}$$
$$x\geq \frac{32}{11} \text{ or } x\leq \frac{3}{4}$$

26. $\frac{1}{2}x-3<5x$ or $\frac{2}{5}x-5>6x$

Inequality 1

$$2\left(\frac{1}{2}x-3\right)<2(5x)$$
$$x-6<10x$$
$$-9x<6$$
$$x>-\frac{2}{3}$$

Inequality 2

$$5\left(\frac{2}{5}x-5\right)>5(6x)$$
$$2x-25>30x$$
$$-28x>25$$
$$x<-\frac{25}{28}$$
$$x>-\frac{2}{3} \text{ or } x<-\frac{25}{28}$$

27.

$$37.002\leq 0.554x-2.886\leq 77.998$$
$$37.002+2.886\leq 0.554x-2.886+2.886\leq 77.998+2.886$$
$$39.888\leq 0.554x\leq 80.884$$
$$\frac{39.888}{0.554}\leq \frac{0.554x}{0.554}\leq \frac{80.884}{0.554}$$
$$72\leq x\leq 146$$

The interval notation is $[72,146]$.

28.

$$70\leq \frac{60+88+73+65+x}{5}<80$$
$$70\leq \frac{286+x}{5}<80$$
$$5(70)\leq 5\left(\frac{286+x}{5}\right)\leq 5(80)$$
$$350\leq 286+x\leq 400$$
$$350-286\leq 286-286+x\leq 400-286$$
$$64\leq x<114$$

The interval notation is $[64,114)$.

Section 1.8 Exercises

29. **a.** $p \geq 0.1$

b. Considering x as a discrete variable representing the number of drinks, then if $x \geq 6$, the 220-lb male is intoxicated.

30. **a.** $V < 8000$

b. $t \leq 3$

31.

$$F \leq 32$$
$$\frac{9}{5}C + 32 \leq 32$$
$$\frac{9}{5}C \leq 0$$
$$C \leq 0$$

A Celsius temperature at or below zero degrees is "freezing."

32.

$$C \geq 100$$
$$\frac{5}{9}(F - 32) \geq 100$$
$$9\left[\frac{5}{9}(F - 32)\right] \geq 9[100]$$
$$5F - 160 \geq 900$$
$$5F \geq 1060$$
$$F \geq 212$$

A Fahrenheit temperature at or above 212 degrees is "boiling."

33. Position 1 income $= 3100$

Position 2 income $= 2000 + 0.05x$, where x represents the sales within a given month

When does the income from the second position exceed the income from the first position? Consider the inequality

$$2000 + 0.05x > 3100$$
$$0.05x > 1100$$
$$x > \frac{1100}{0.05}$$
$$x > 22,000$$

When monthly sales exceed $22,000, the second position is more profitable than the first position.

34. Original value $= (1000)(22) = \$22,000$

$$\text{Adjusted value} = 22,000 - (22,000)(20\%)$$
$$= 22,000 - 4400$$
$$= 17,600$$

Let $x =$ percentage increase

$$17,600 + 17,600x > 22,000$$
$$17,600x > 4400$$
$$x > \frac{4400}{17,600}$$
$$x > 0.25$$
$$x > 25\%$$

The percentage increase must be greater than 25% in order to ensure a profit.

35. Let $x =$ Jill's final exam grade.

$$80 \le \frac{78+69+92+81+2x}{6} \le 89$$

$$6(80) \le 6\left(\frac{78+69+92+81+2x}{6}\right) \le 6(89)$$

$$480 \le 320 + 2x \le 534$$

$$480 - 320 \le 320 - 320 + 2x \le 534 - 320$$

$$160 \le 2x \le 214$$

$$\frac{160}{2} \le \frac{2x}{2} \le \frac{214}{2}$$

$$80 \le x \le 107$$

If the final exam does not contain any bonus points, Jill needs to score between 80 and 100 to earn a grade of B for the course.

36. Let $x =$ John's final exam grade.

$$70 \le \frac{78+62+82+2x}{5} \le 79$$

$$5(70) \le 5\left(\frac{78+62+82+2x}{5}\right) \le 5(79)$$

$$350 \le 222 + 2x \le 395$$

$$128 \le 2x \le 173$$

$$\frac{128}{2} \le \frac{2x}{2} \le \frac{173}{2}$$

$$64 \le x \le 86.5$$

John needs to score between 64 and 86.5 to earn a grade of C for the course.

37. Let $x = 6,$ and solve for $p.$

$$30p - 19(6) = 1$$

$$30p - 114 = 1$$

$$30p = 115$$

$$p = \frac{115}{30} = 3.8\overline{3}$$

Let $x = 10,$ and solve for $p.$

$$30p - 10(19) = 1$$

$$30p - 190 = 1$$

$$30p = 191$$

$$p = \frac{191}{30} = 6.3\overline{6}$$

Therefore, between 1996 and 2000, the percentage of marijuana use is between 3.83% and 6.37%. In symbols, $3.83 \le p \le 6.37.$

38. If the years are between 1950 and 1992, then $0 \le x \le 42$. Therefore, cigarette production is given by:

$$9.3451(0) + 649.3385 \le y \le 9.3451(42) + 649.3385$$

$$649.3385 \le y \le 392.4942 + 649.3385$$

$$649.3385 \le y \le 1041.8327$$

or rounding to zero decimal places

$$649 \le y \le 1042$$

Between 1950 and 1992, cigarette production is between 649 and 1042 cigarettes per person per year inclusive.

39. $y \geq 1000$

$0.97x + 128.3829 \geq 1000$

$0.97x \geq 871.6171$

$x \geq \dfrac{871.6171}{0.97}$

$x \geq 898.57$ or approximately $x \geq 899$

Old scores greater than or equal to 899 are equivalent to new scores.

40. $y < 1000$

$9.3451x + 649.3385 < 1000$

$9.3451x < 350.6615$

$x < \dfrac{350.6615}{9.3451}$

$x < 37.5235685$

Prior to 1997 cigarette production is less than 1000 cigarettes per person per year.

41. Let x represent the actual life of the HID headlights.

$1500 - 10\%(1500) \leq x \leq 1500 + 10\%(1500)$

$1500 - 150 \leq x \leq 1500 + 150$

$1350 \leq x \leq 1650$

42. Remember to convert years into months.

$4(12) < y < 6(12)$

$48 < 0.554x - 2.886 < 72$

$48 + 2.886 < 0.554x - 2.886 + 2.886 < 72 + 2.886$

$50.886 < 0.554x < 74.886$

$\dfrac{50.886}{0.554} < \dfrac{0.554x}{0.554} < \dfrac{74.886}{0.554}$

$91.85198556 < x < 135.1732852$

or approximately,

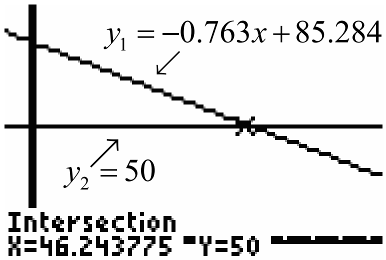
$92 < x < 135$

The prison sentence needs to be between 92 months and 135 months.

43. a. Let $y > 50$.

$-0.763x + 85.284 > 50$

Applying the intersection of graphs method:



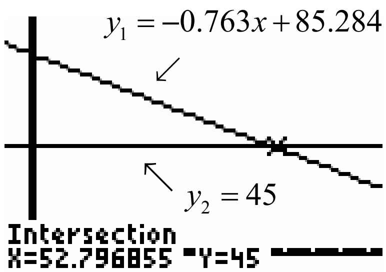
[–5, 75] by [–5, 100]

When $x < 46.24, y > 50$.
The marriage rate per 1000 women is greater than 50 prior to 1996.

b. Let $y < 45$.

$-0.763x + 85.284 > 45$

Applying the intersection of graphs method:



[–5, 75] by [–5, 100]

When $x > 52.80, y < 45$.
The marriage rate per 1000 women will be less than 45 beyond 2002.

44. Note that W and M are in thousands.

$M \geq 100$

$0.959W - 1.226 \geq 100$

$0.959W \geq 101.226$

$W \geq \dfrac{101.226}{0.959}$

$W \geq 105.5537018$

The median salary for whites needs to be approximately \$105,533 or greater.

45. a. Since the rate of increase is constant, the equation modeling the value of the home is linear.

$$m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{270,000 - 190,000}{4 - 0} = \frac{80,000}{4} = 20,000$$

Solving for the equation:

$y - y_1 = m(x - x_1)$

$y - 190,000 = 20,000(x - 0)$

$y - 190,000 = 20,000x$

$y = 20,000x + 190,000$

b. $y > 400,000$

$20,000x + 190,000 > 400,000$

$20,000x > 210,000$

$x > \dfrac{210,000}{20,000}$

$x > 10.5$

2010 corresponds to

$x = 2010 - 1996 = 14$.

Therefore, $11 \leq x < 14$.

Or, $y > 400,000$

between 2007 and 2010.

The value of the home will be greater than $400,000 between 2007 and 2010.

46. Cost of 12 cars $= (12)(32,500) = 390,000$

Cost of 11 cars $= (11)(32,500) = 357,500$

Let $x =$ profit on the sale of the 12^{th} car.

$(5.5\%)(357,500) + x \geq (6\%)(390,000)$

$19,662.50 + x \geq 23,400$

$x \geq 3737.50$

The price of the 12^{th} car needs to be at least $32,500 + 3737.50 = 36,237.50$ or $\$36,238$.

47.

$$P(x) > 10,900$$
$$6.45x - 2000 > 10,900$$
$$6.45x > 12,900$$
$$x > \frac{12,900}{6.45}$$
$$x > 2000$$

A production level above 2000 units will yield a profit greater than $10,900.

48. $P(x) > 84,355$

$-40,255 + 9.80x > 84,355$

$9.80x > 124,610$

$x > \dfrac{124,610}{9.80}$

$x > 12,715.30612$

Rounding since the data is discrete:

$x > 12,715$

The number of units sold needs to exceed 12,715.

49.

$$P(x) \geq 0$$
$$6.45x - 9675 \geq 0$$
$$6.45x \geq 9675$$
$$x \geq \frac{9675}{6.45}$$
$$x \geq 1500$$

Sales of 1500 feet or more of PVC pipe will avoid a loss for the hardware store.

50. Generating a loss implies that $P(x) < 0$.

$P(x) < 0$

$-40,255 + 9.80x < 0$

$9.80x < 40,255$

$x < \dfrac{40,255}{9.80}$

$x < 4107.653061$

Rounding since the data is discrete:

$x < 4108$

Producing and selling fewer than 4108 units results in a loss.

51. Recall that Profit = Revenue $-$ Cost.

Let $x =$ the number of boards manufactured and sold.

$P(x) = R(x) - C(x)$

$R(x) = 489x$

$C(x) = 125x + 345,000$

$P(x) = 489x - (125x + 345,000)$

$P(x) = 489x - 125x - 345,000$

$P(x) = 364x - 345,000$

To make a profit, $P(x) > 0$.

$364x - 345,000 > 0$

52. $T \le 85$

$0.43m + 76.8 \le 85$

$0.43m \le 8.2$

$m \le \dfrac{8.2}{0.43}$

$m \le 19.06976744$ or approximately,

$m \le 19$

The temperature will be at most 85°F for the first 19 minutes.

53.

$$245 < y < 248$$
$$245 < 0.155x + 244.37 < 248$$
$$245 - 244.37 < 0.155x + 244.37 - 244.37 < 248 - 244.37$$
$$0.63 < 0.155x < 3.63$$
$$\frac{0.63}{0.155} < \frac{0.155}{0.155}x < \frac{3.63}{0.155}$$
$$4.06 < x < 23.42$$

Considering x as a discrete variable yields $4 < x < 23$.

From 1974 until 1993 the reading scores were between 245 and 248.

54. a. $65.4042 - 0.3552x < 30$

$-0.3552x < -35.4042$

$x > \dfrac{-35.4042}{-0.3552}$ (Note the inequality sign switch.)

$x > 99.67398649 \approx 100$

The voting percentage is less than 30 after the year 2050.

b. $65.4042 - 0.3552x > 75$

$-0.3552x > 9.5958$

$x < \dfrac{9.5958}{-0.3552}$ (Note the inequality sign switch.)

$x < -27.0152027$

$x \approx -27$

The voting percentage is greater than 75 before the year 1923.

c. $50 \le 65.4042 - 0.3552x \le 60$

$50 - 65.4042 \le 65.4042 - 65.4042 - 0.3552x \le 60 - 65.4042$

$-15.4042 \le -0.3552x \le -5.4042$

$\frac{-15.4042}{-0.3552} \ge \frac{-0.3552x}{-0.3552} \ge \frac{-5.4042}{-0.3552}$ (Note the inequality sign switch.)

$43.36768018 \ge x \ge 15.21396396$

$43 \ge x \ge 15$

$15 \le x \le 43$

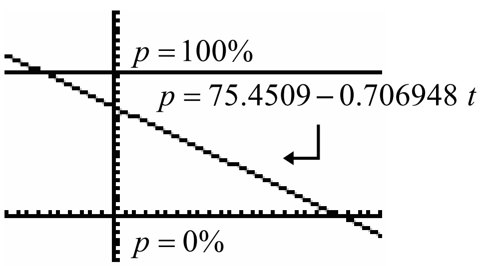
The voting percentage is between 50and 60 between the years 1965 and 1993 inclusive.

55. a. $t = 1998 - 1975 = 23$

$p(23) = 75.4509 - 0.706948(23)$
$= 75.4509 - 16.259804$
$= 59.191096 \approx 59.2\%$

In 1998 the percent of high school seniors who have tried cigarettes is estimated to be 59.2%.

b. $0 \le p \le 100$



X	Y1	Y2
-37	101.61	0
-36	100.9	0
-35	100.19	0
-34	99.487	0
-33	98.78	0
-32	98.073	0
-31	97.366	0

X= -34

X	Y1	Y2
104	1.9283	0
105	1.2214	0
106	.51441	0
107	-.1925	0
108	-.8995	0
109	-1.606	0
110	-2.313	0

X=106

$-34 \le t \le 106$

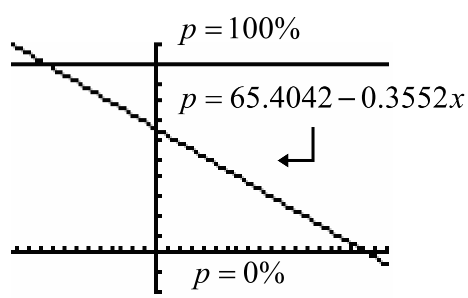
c. Considering part *b* above, the model is valid between $1975 - 34 = 1941$ and $1975 + 106 = 2081$ inclusive. It is not valid before 1941 or after 2081.

56. a. $t = 2005 - 1950 = 55$

$p(55) = 65.4042 - 0.3552(55)$
$= 45.8682 \approx 45.9\%$

In 2005 the percent of the voting population who vote in the presidential election is estimated to be 45.9%.

b. $0 \le p \le 100$



X	Y_2	Y_3
-100	100	100.92
-99	100	100.57
-98	100	100.21
-97	100	99.859
-96	100	99.503
-95	100	99.148
-94	100	98.793

$Y_3=99.8586$

X	Y_2	Y_3
181	100	1.113
182	100	.7578
183	100	.4026
184	100	.0474
185	100	-.3078
186	100	-.663
187	100	-1.018

$Y_3=.0474$

$-97 \le x \le 184$

c. Considering part *b* above, the model is valid between $1950-97=1853$ and $1950+184=2134$ inclusive. It is not valid before 1853 or after 2134.

Chapter 1 Skills Check

1. The table represents a function because every x matches with exactly one y.

2. Domain: $\{-3,-1,1,3,5,7,9,11,13\}$
Range: $\{9,6,3,0,-3,-6,-9,-12,-15\}$

3. $f(3)=0$

4. Yes. The first differences are constant. The slope is
$m=\dfrac{y_2-y_1}{x_2-x_1}=\dfrac{6-9}{-1-(-3)}=\dfrac{-3}{2}=-\dfrac{3}{2}.$

Calculating the equation:

$$y-y_1=m(x-x_1)$$
$$y-9=-\frac{3}{2}(x-(-3))$$
$$y-9=-\frac{3}{2}x-\frac{9}{2}$$
$$y=-\frac{3}{2}x-\frac{9}{2}+9$$
$$y=\frac{3}{2}x-\frac{9}{2}+\frac{18}{2}$$
$$y=\frac{3}{2}x+\frac{9}{2}$$

5. **a.** $C(3)=16-2(3)^2=16-2(9)$
$=16-18=-2$

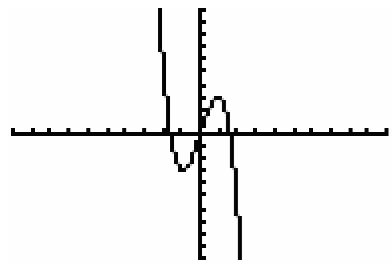
b. $C(-2)=16-2(-2)^2=16-2(4)$
$=16-8=8$

c. $C(-1)=16-2(-1)^2=16-2(1)$
$=16-2=14$

6. **a.** $f(-3)=1$

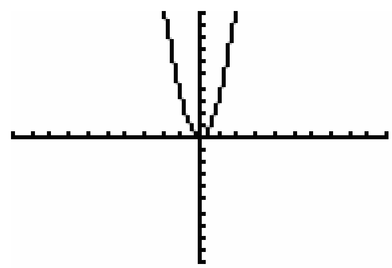
b. $f(-3)=-10$

7.



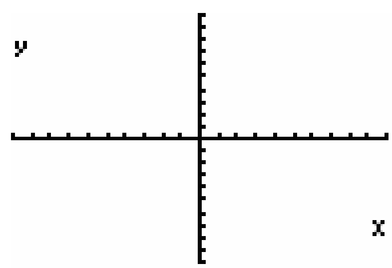
[–10, 10] by [–10, 10]

8.

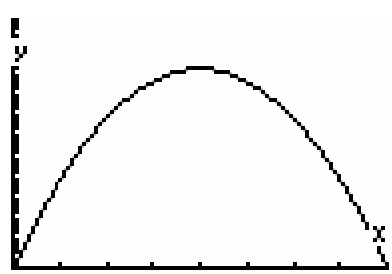


[–10, 10] by [–10, 10]

9.



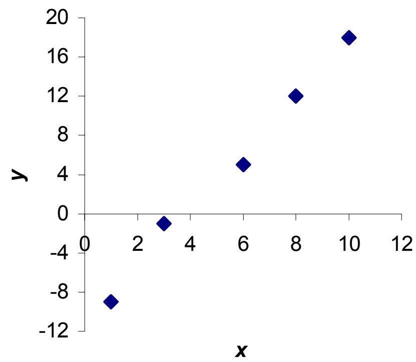
[–10, 10] by [–10, 10]



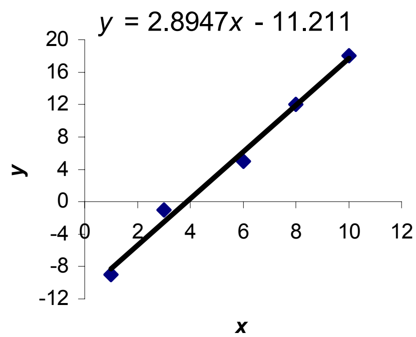
[0, 40] by [0, 5000]

The second view is better.

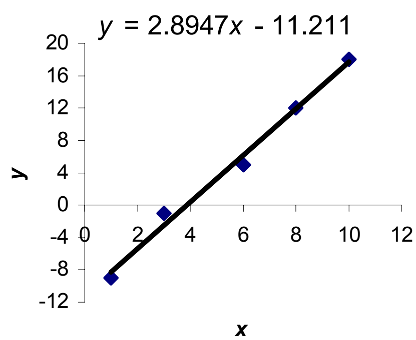
10.



11.



12.



13. No. Data points do not necessarily fit a linear model exactly.

14. $m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{-16-6}{8-(-4)} = \frac{-22}{12} = -\frac{11}{6}$

15. a. x-intercept: Let $y = 0$ and solve for x.

$2x - 3(0) = 12$

$2x = 12$

$x = 6$

y-intercept: Let $x = 0$ and solve for y.

$2(0) - 3y = 12$

$-3y = 12$

$y = -4$

x-intercept: (6, 0), y-intercept: (0, –4)

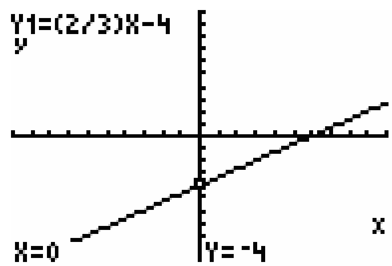
b. Solving for y:

$2x - 3y = 12$

$-3y = -2x + 12$

$\frac{-3y}{-3} = \frac{-2x+12}{-3}$

$y = \frac{2}{3}x - 4$



[–10, 10] by [–10, 10]

16. Since the model is linear, the rate of change is equal to the slope of the equation. The slope, m, is $\frac{2}{3}$.

17. $m = -6$.

$(0,3)$ is the y-intercept.

18. Since the function is linear, the rate of change is the slope. $m = -6$.

19. $y = mx + b$

$y = \frac{1}{3}x + 3$

20. $y - y_1 = m(x - x_1)$

$y - (-6) = -\frac{3}{4}(x - 4)$

$y + 6 = -\frac{3}{4}x + 3$

$y = -\frac{3}{4}x - 3$

21. The slope is

$m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{6-3}{2-(-1)} = \frac{3}{3} = 1.$

Solving for the equation:

$y - y_1 = m(x - x_1)$

$y - 6 = 1(x - 2)$

$y - 6 = x - 2$

$y = x + 4$

22. $\begin{cases} 3x + 2y = 0 & (Eq1) \\ 2x - y = 7 & (Eq2) \end{cases}$

$\begin{cases} 3x + 2y = 0 & (Eq1) \\ 4x - 2y = 14 & 2\times(Eq2) \end{cases}$

$7x = 14$

$x = 2$

Substituting to find y

$3(2) + 2y = 0$

$6 + 2y = 0$

$2y = -6$

$y = -3$

The solution is $(2, -3)$.

23. $\begin{cases} 3x + 2y = -3 & (Eq1) \\ 2x - 3y = 3 & (Eq2) \end{cases}$

$\begin{cases} 9x + 6y = -9 & 3\times(Eq1) \\ 4x - 6y = 6 & 2\times(Eq2) \end{cases}$

$13x = -3$

$x = -\frac{3}{13}$

Substituting to find y

$3\left(-\frac{3}{13}\right) + 2y = -3$

$-\frac{9}{13} + 2y = -\frac{39}{13}$

$2y = -\frac{30}{13}$

$y = -\frac{15}{13}$

The solution is $\left(-\frac{3}{13}, -\frac{15}{13}\right)$.

24. $\begin{cases} -4x + 2y = -14 & (Eq1) \\ 2x - y = 7 & (Eq2) \end{cases}$

$\begin{cases} -4x + 2y = -14 & (Eq1) \\ 4x - 2y = 14 & 2\times(Eq2) \end{cases}$

$0 = 0$

Dependent system. Infinitely many solutions.

25. $\begin{cases} -6x + 4y = 10 & (Eq1) \\ 3x - 2y = 5 & (Eq2) \end{cases}$

$\begin{cases} -6x + 4y = 10 & (Eq1) \\ 6x - 4y = 10 & 2\times(Eq2) \end{cases}$

$0 = 10$

No solution. Lines are parallel.

26. $\begin{cases} 2x+3y=9 & (Eq1) \\ -x-y=-2 & (Eq2) \end{cases}$

$\begin{cases} 2x+3y=9 & (Eq1) \\ -2x-2y=-4 & 2\times(Eq2) \end{cases}$

$y=5$

Substituting to find x

$2x+3(5)=9$

$2x+15=9$

$2x=-6$

$x=-3$

The solution is $(-3,5)$.

27. $\begin{cases} 2x+y=-3 & (Eq1) \\ 4x-2y=10 & (Eq2) \end{cases}$

$\begin{cases} 4x+2y=-6 & 2\times(Eq1) \\ 4x-2y=10 & (Eq2) \end{cases}$

$8x=4$

$x=\dfrac{1}{2}$

Substituting to find y

$2\left(\dfrac{1}{2}\right)+y=-3$

$1+y=-3$

$y=-4$

The solution is $\left(\dfrac{1}{2},-4\right)$.

28. **a.** $f(x+h)=5-4(x+h)$

$=5-4x-4h$

b. $f(x+h)-f(x)$

$=[5-4(x+h)]-[5-4x]$

$=5-4x-4h-5+4x$

$=-4h$

c. $\dfrac{f(x+h)-f(x)}{h}$

$=\dfrac{-4h}{h}$

$=-4$

29. **a.** $f(x+h)$

$=10(x+h)-50$

$=10x+10h-50$

b. $f(x+h)-f(x)$

$=[10x+10h-50]-[10x-50]$

$=10x+10h-50-10x+50$

$=10h$

c. $\dfrac{f(x+h)-f(x)}{h}$

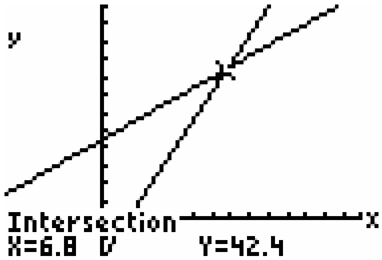
$=\dfrac{10h}{h}$

$=10$

30. **a.**

$$\begin{aligned} 3x+22&=8x-12 \\ 3x-8x+22&=8x-8x-12 \\ -5x+22&=-12 \\ -5x+22-22&=-12-22 \\ -5x&=-34 \\ \frac{-5x}{-5}&=\frac{-34}{-5} \\ x&=\frac{34}{5} \end{aligned}$$

b. Applying the intersections of graphs method yields $x=6.8$.



[–5, 15] by [–10, 60]

31. a. $\frac{3(x-2)}{5} - x = 8 - \frac{x}{3}$

LCM: 15

$15\left(\frac{3(x-2)}{5} - x\right) = 15\left(8 - \frac{x}{3}\right)$

$3\big(3(x-2)\big) - 15x = 120 - 5x$

$3(3x-6) - 15x = 120 - 5x$

$9x - 18 - 15x = 120 - 5x$

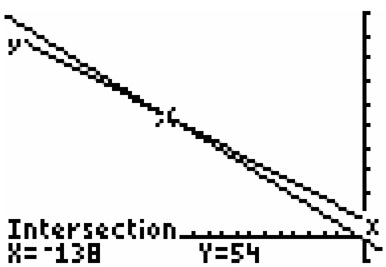
$-6x - 18 = 120 - 5x$

$-1x - 18 = 120$

$-1x = 138$

$x = -138$

b. Applying the intersections of graphs method yields $x = -138$.



[–250, 10] by [–10, 100]

32. If $x = 0$, then $y = (0)^2 = 0$.

If $x = 3$, then $y = (3)^2 = 9$.

The average rate of change between the points is $\frac{y_2 - y_1}{x_2 - x_1} = \frac{9-0}{3-0} = \frac{9}{3} = 3.$

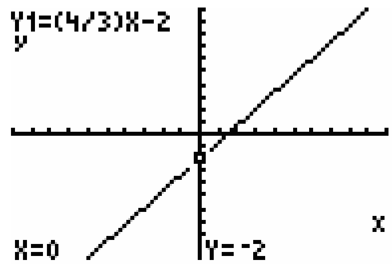
33. Solving for y:

$4x - 3y = 6$

$-3y = -4x + 6$

$y = \frac{-4x+6}{-3}$

$y = \frac{4}{3}x - 2$



34. Algebraically:

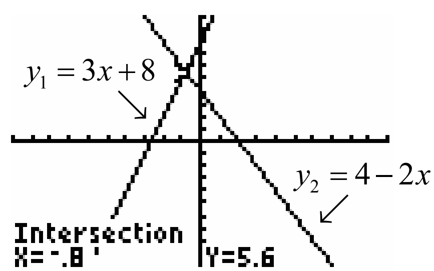
$3x + 8 < 4 - 2x$

$5x + 8 < 4$

$5x < -4$

$x < -\frac{4}{5}$

Graphically:



[–10, 10] by [–10, 10]

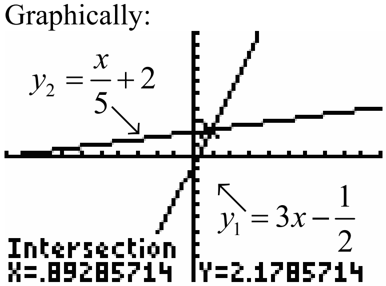
$3x + 8 < 4 - 2x$ implies that the solution region is $x < -\frac{4}{5}$.

The interval notation is $\left(-\infty, -\frac{4}{5}\right)$.

35. Algebraically:

$$3x - \frac{1}{2} \le \frac{x}{5} + 2$$
$$10\left(3x - \frac{1}{2}\right) \le 10\left(\frac{x}{5} + 2\right)$$
$$30x - 5 \le 2x + 20$$
$$28x - 5 \le 20$$
$$28x \le 25$$
$$x \le \frac{25}{28}$$

Graphically:



[–10, 10] by [–10, 10]

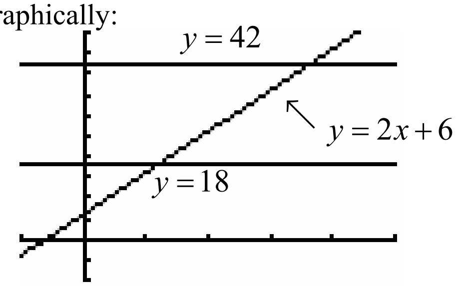
$3x - \frac{1}{2} \le \frac{x}{5} + 2$ implies that the solution region is $x \le \frac{25}{28}$.

The interval notation is $\left(-\infty, \frac{25}{28}\right]$.

36. Algebraically:

$$18 \le 2x + 6 < 42$$
$$18 - 6 \le 2x + 6 - 6 < 42 - 6$$
$$12 \le 2x < 36$$
$$\frac{12}{2} \le \frac{2x}{2} < \frac{36}{2}$$
$$6 \le x < 18$$

Graphically:



[–5, 25] by [–10, 50]

$18 \le 2x + 6 < 42$ implies that the solution region is $6 \le x < 18$.

The interval notation is $[6, 18)$.

Chapter 1 Review Exercises

37. a. Yes. Every year matches with exactly one Democratic Party percentage.

b. $f(1992) = 82$. The table indicates that in 19992, 82% of African American voters supported a Democratic candidate for president.

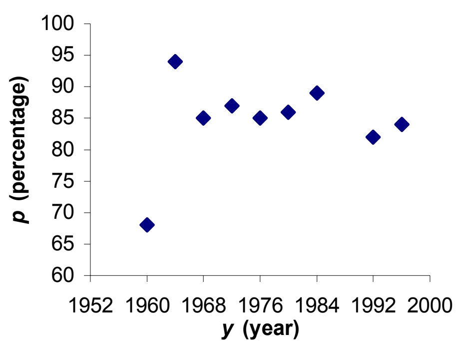
c. When $f(y) = 94, y = 1964$. The table indicates that in 1964, 94% of African American voters supported a Democratic candidate for president.

38. a. The domain is $\{1960, 1964, 1968, 1972, 1976, 1980, 1984, 1992, 1996\}$.

b. No. 1982 was not a presidential election year.

c. Discrete. The input values are the presidential election years. There are 4-year gaps between the inputs.

39.



40. a.
$$m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{84-85}{1996-1968} = \frac{-1}{28} \approx -0.357$$

b.
$$\frac{f(b)-f(a)}{b-a} = \frac{84-85}{1996-1968} = \frac{-1}{28} \approx -0.357$$

c. No.

$$\frac{f(b)-f(a)}{b-a} = \frac{86-85}{1980-1968} = \frac{1}{28} \approx 0.357$$

d. No. Consider the scatter plot in problem 39 above.

41. a. Every amount borrowed matches with exactly one monthly payment. The change in y is fixed at 89.62 for a fixed change in x of 5000.

b. $f(25{,}000) = 448.11$. Therefore, borrowing \$25,000 to buy a car from the dealership results in a monthly payment of \$448.11.

c. If $f(A) = 358.49$, then $A = 20{,}000$.

42. a. Domain: $\{10{,}000, 15{,}000, 20{,}000, 25{,}000, 30{,}000\}$

Range: $\{179.25, 268.87, 358.49\ 448.11, 537.73\}$

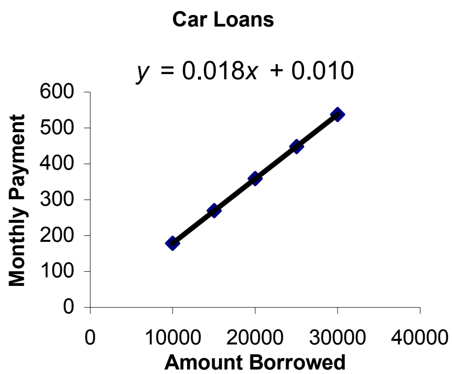
b. No. \$12,000 is not in the domain of the function.

c. Discrete. There are gaps between the possible inputs.

43. a. Yes. As each amount borrowed increases by \$5000, the monthly payment increases by \$89.62.

b. Yes. Since the first differences are constant, a linear model will fit the data exactly.

44. a.



$P = f(A) = 0.018A + .010$

b. $f(28{,}000) = 0.018(28{,}000) + 0.010$
$= 504.01$
The predicted monthly payment on a car loan of \$28,000 is \$504.01

c. Yes. Any input could be used for A.

d.
$$f(A) \le 500$$
$$0.018A + 0.010 \le 500$$
$$0.018A \le 499.99$$
$$A \le \frac{499.99}{0.018}$$
$$A \le 27{,}777.\overline{2}$$
The loan amount needs to be less than or equal to approximately \$27,777.22.

45. a. $f(1960) = 15.9$. A 65-year old woman in 1960 is expected to live 15.9 more years. Her overall life expectancy is 80.9 years.

b. $f(2010) = 19.4$. A 65-year old woman in 2010 has a life expectancy of 84.4 years.

c. $f(1990) = 19$

46. a. $g(2020) = 16.9$.
A 65-year old man in 2020 is expected to live 16.9 more years. His overall life expectancy is 81.9 years.

b. $g(1950) = 12.8$. A 65-year old man in 1950 has a life expectancy of 77.8 years.

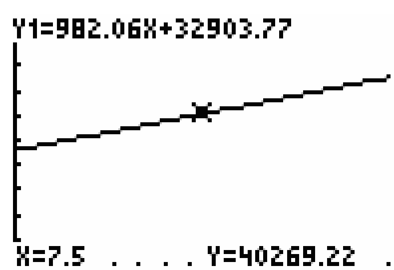
c. $g(1990) = 15$

47. a. $t = 2000 - 1990 = 10$
$f(10) = 982.06(10) + 32{,}903.77$
$f(10) = 42{,}724.37$

b. $t = 15$
$f(15) = 982.06(15) + 32{,}903.77$
$f(15) = 47{,}634.67$
Based on the model in 2005 average teacher salaries will be \$47,634.67.

c. Increasing

48. a.



[0, 15] by [10,000, 60,000]

b. From 1990 through 2005

49. a. $m = \frac{y_2 - y_1}{x_2 - x_1}$

$= \frac{14.5 - 12.0}{1999 - 1992}$

$= \frac{2.5}{7} \approx 0.357$

b. Assuming that drug use follows a linear model, the annual rate of change is equal to the slope calculated in part a). Each year, the number of people using illicit drugs increases by 0.357 million or 357,000.

50. $f(x) = 4500$

51. a. Let $x =$ the number of months past December 1997, and $f(x) =$ average weekly hours worked. Then $f(x) = 34.6$.

b. Yes. The average rate of change is zero.

52. a. Let $x =$ monthly sales.

$2100 = 1000 + 5\%x$

$2100 = 1000 + 0.05x$

$1100 = 0.05x$

$x = \frac{1100}{0.05} = 22,000$

If monthly sales are $22,000, both positions will yield the same monthly income.

b. Considering the solution from part a), if sales exceed $22,000 per month, the 2nd position will yield a greater salary.

53. $\text{Profit} = 10\%(24,000 \cdot 12) = 28,800$

$\text{Cost} = 24,000 \cdot 12 = 288,000$

$\text{Revenue} = 8(24,000 + 12\% \cdot 24,000) + 4x$,

where x is the selling price of the remaining four cars.

Profit = Revenue − Cost

$28,800 = (215,040 + 4x) - 288,000$

$28,800 = 4x - 72,960$

$4x = 101,760$

$x = \frac{101,760}{4} = 25,440$

The remaining four cars should be sold for $25,440 each.

54. Let $x =$ amount invested in the safe account, and let $420,000 - x =$ amount invested in the risky account.

$6\%x + 10\%(420,000 - x) = 30,000$

$0.06x + 42,000 - 0.10x = 30,000$

$-0.04x = -12,000$

$x = \frac{-12,000}{-0.04}$

$x = 300,000$

The couple invests $300,000 in the safe account and $120,000 in the risky account.

55. Let $y = 285$, and solve for x.

$285 = -0.629x + 293.871$

$285 - 293.871 =$

$-0.629x + 293.871 - 293.871$

$-8.871 = -0.629x$

$\frac{-0.629x}{-0.629} = \frac{-8.871}{-0.629}$

$x \approx 14.1$

Therefore, the writing score is 285 in $1980 + 14 = 1994$.

56. a. $R(120) = 564(120) = 67,680$

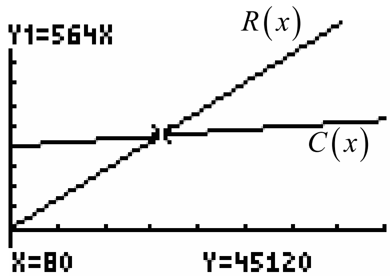
b. $C(120) = 40{,}000 + 64(120) = 47{,}680$

c. Marginal Cost $= \overline{MC} = 64$

Marginal Revenue $= \overline{MR} = 564$

d. $m = 64$

e.



[0, 200] by [0, 200,000]

57. a. $P(x) = 564x - (40{,}000 + 64x)$
$= 564x - 40{,}000 - 64x$
$= 500x - 40{,}000$

b. $P(120) = 500(120) - 40{,}000$
$= 60{,}000 - 40{,}000$
$= 20{,}000$

c. Break-even occurs when $R(x) = C(x)$ or alternately $P(x) = 0$.

$500x - 40{,}000 = 0$

$500x = 40{,}000$

$x = \dfrac{40{,}000}{500} = 80$

80 units represents break-even for the company.

d. $\overline{MP}$ = the slope of $P(x) = 500$

e. $\overline{MP} = \overline{MR} - \overline{MC}$

58. a. Let $x = 0$, and solve for y.

$y + 3000(0) = 300{,}000$

$y = 300{,}000$

The initial value of the property is $300,000.

b. Let $y = 0$, and solve for x.

$0 + 3000x = 300{,}000$

$3000x = 300{,}000$

$x = 100$

The value of the property after 100 years is zero dollars.

59. a. $m = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{895 - 455}{250 - 150} = \dfrac{440}{100} = 4.4$

The average rate of change is $4.40 per unit.

b. For a linear function, the slope is the average rate of change. Referring to part a), the slope is 4.4.

c. $y - y_1 = m(x - x_1)$

$y - 455 = 4.4(x - 150)$

$y - 455 = 4.4x - 660$

$y = 4.4x - 205$

$P(x) = 4.4x - 205$

d. $\overline{MP}$ = the slope of $P(x) = 4.4$ or $4.40 per unit.

e. Break-even occurs when $R(x) = C(x)$ or alternately $P(x) = 0$.

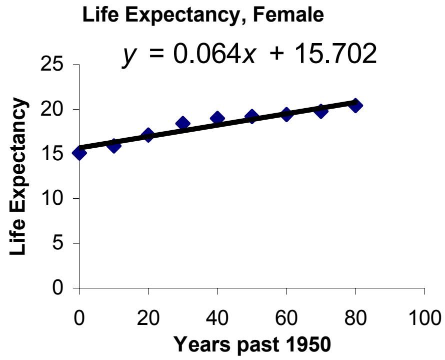
$4.4x - 205 = 0$

$4.4x = 205$

$x = \dfrac{205}{4.4} = 46.59\overline{09} \approx 47$

The company will break even selling approximately 47 units.

60. a.

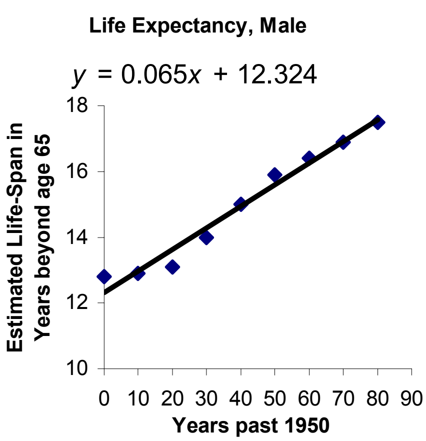


b. See part a) above.

c. $f(104) = 0.064(104) + 15.702$
$= 22.358$
In 2054 the average woman is expected to live 22.36 years beyond age 65. Her life expectency is 87.36 years.

d. $y \geq 84 - 65$
$0.064x + 15.702 \geq 19$
$0.064x \geq 3.298$
$x \geq \frac{3.298}{0.064}$
$x \geq 51.53$
For years 2002 and beyond, the average woman is expected to live at least 84 years.

61. a.



b. See part a) above.

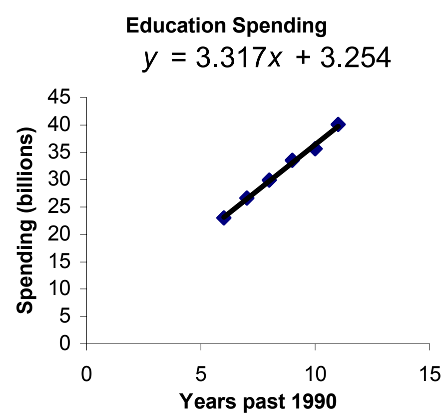
c. $g(130) = 0.065(130) + 12.324$
$= 8.45 + 12.324$
$= 20.774 \approx 20.8$
In 2080 (1950 + 130), a 65-year old male is expected to live 20.8 more years. The overall life expectancy is 85.8 years.

d. A life expectancy of 90 years translates into $90 - 65 = 25$ years beyond age 65. Therefore, let $g(x) = 25$.
$0.065x + 12.324 = 25$
$0.065x = 25 - 12.324$
$0.065x = 12.676$
$x = \frac{12.676}{0.065} = 195.0153846 \approx 195$

In approximately the year 2145 (1950 +195), male life expectancy will be 90 years.

e. A life expectancy of 81 years translates into $81 - 65 = 16$ years beyond age 65.
$g(x) \leq 16$
$0.065x + 12.324 \leq 16$
$0.065x \leq 3.676$
$x \leq \frac{3.676}{0.065}$
$x \leq 56.6$

62. a.



A linear model is reasonable.

b. See part a) above.

c. $y = 3.317x + 3.254$

$y = 3.317(2002 - 1990) + 3.254$

$y = 3.317(12) + 3.254$

$y = 43.058$

Approximately \$43.1 billion

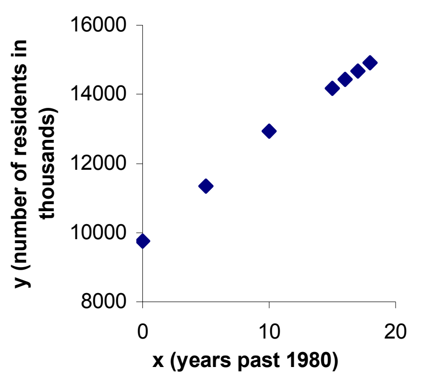
Using the unrounded model:

X	Y1
7	26.474
8	29.791
9	33.109
10	36.426
11	39.743
12	43.06
13	46.377

X=12

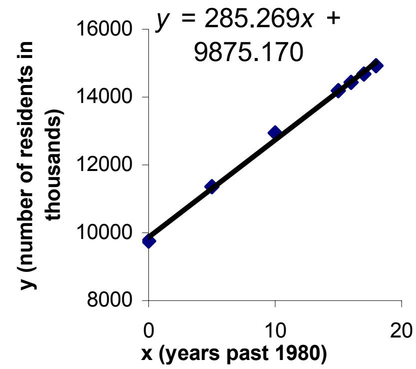
The unrounded model predicts that education spending in 2002 will be \$43.06 billion.

63. a.



Yes. A linear model would fit the data well. The data points lie approximately along a line.

b.



c. In 2002, $x = 2002 - 1980 = 22$.

$y = 285.269(22) + 9875.170$

$= 6275.918 + 9875.170$

$= 16{,}151.088$

In 2002, the predicted population is 16,151,088.

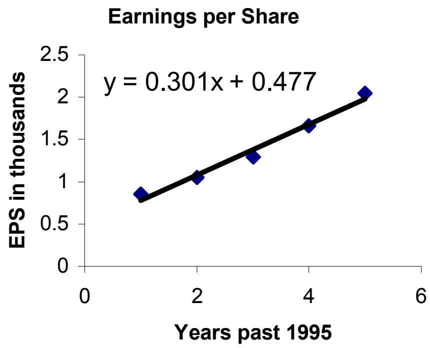
Using the unrounded model:

X	Y1
18	15010
19	15295
20	15581
21	15866
22	[illegible]
23	16436
24	16722

Y1=16151.0938134

The unrounded model predicts that the population in 2002 will be approximately 16,151,094.

64. a.



A linear model is reasonable.

b. See part a) above.

c. See part a) above. The line seems to fit the data points very well.

65. a.

$$\begin{aligned} y &> 48.66 \\ -0.763x + 85.284 &> 48.66 \\ -0.763x &> -36.624 \\ x &< \frac{-36.624}{-0.763} \quad \text{(Note the inequality sign switch.)} \\ x &< 48 \end{aligned}$$

For years less than $1950 + 48 = 1998,$ the marriage rate is less than 48.66 per 1000 women.

b.

$$\begin{aligned} y &< 41.03 \\ -0.763x + 85.284 &< 41.03 \\ -0.763x &< -44.254 \\ x &> \frac{-44.254}{-0.763} \quad \text{(Note the inequality sign switch.)} \\ x &> 58 \end{aligned}$$

For years beyond $1950 + 58 = 2008,$ the marriage rate per 1000 women will be less than 41.03.

66. $30p-19x=1$

Let $p=3.2$.

$30(3.2)-19x=1$

$96-19x=1$

$-19x=-95$

$x=\frac{-95}{-19}=5$

The year is $1990+5=1995$.

Let $p=7$.

$30(7)-19x=1$

$210-19x=1$

$-19x=-209$

$x=\frac{-209}{-19}=11$

The year is $1990+11=2001$

From 1995 until 2001, Marijuana use is in the range of 3.2%-7%.

67. Let $3(12)\le x\le 5(12)$ or

$36\le x\le 60$.

Then

$0.554(36)-2.886\le y\le 0.554(60)-2.886$.

Therefore, $17.058\le y\le 30.354$. Or, rounding to the nearest month,

$17\le y\le 30$.

The criminal is expected to serve between 17 and 30 months inclusive.

68. Let $x=$ the amount in the safer fund, and $y=$ the amount in the riskier fund.

$$\begin{cases} x+y=240{,}000 & (Eq1) \\ 0.08x+0.12y=23{,}200 & (Eq2) \end{cases}$$

$$\begin{cases} -0.08x-0.08y=-19{,}200 & -0.08\times(Eq1) \\ 0.08x+0.12y=23{,}200 & (Eq2) \end{cases}$$

$0.04y=4000$

$y=\frac{4000}{0.04}=100{,}000$

Substituting to calculate x

$x+100{,}000=240{,}000$

$x=140{,}000$

The safer fund contains \$140,000, while the riskier fund contains \$100,000.

69. Let $x=$ number of units.

$R=C$

$565x=6000+325x$

$240x=6000$

$x=25$

The number of units that produced to create a break even point is 25.

70. Let x = dosage of Medication A, and let y = dosage of Medication B.

$$\begin{cases} 6x+2y=25.2 & (Eq1) \\ \dfrac{x}{y}=\dfrac{2}{3} & (Eq2) \end{cases}$$

Solving $(Eq2)$ for x yields

$3x=2y$

$x=\frac{2}{3}y$

Substituting

$6\left(\frac{2}{3}y\right)+2y=25.2$

$4y+2y=25.2$

$6y=25.2$

$y=4.2$

Substituting to calculate x

$x=\frac{2}{3}(4.2)$

$x=2.8$

Medication A dosage is 2.8 mg while Medication B dosage is 4.2 mg.

71. Let p = price and q = quantity.

$$\begin{cases} 3q+p=340 & (Eq1) \\ -4q+p=-220 & (Eq2) \end{cases}$$

$$\begin{cases} -3q-1p=-340 & -1\times(Eq1) \\ -4q+p=-220 & (Eq2) \end{cases}$$

$-7q=-560$

$q=\frac{-560}{-7}=80$

Substituting to calculate p

$3(80)+p=340$

$240+p=340$

$p=100$

Equilibrium occurs when the price is $100, and the quantity is 80 pairs.

72. Let p = price and q = quantity.

$$\begin{cases} p=\dfrac{q}{10}+8 & (Eq1) \\ 10p+q=1500 & (Eq2) \end{cases}$$

Substituting

$10\left(\frac{q}{10}+8\right)+q=1500$

$q+80+q=1500$

$2q=1420$

$q=710$

Substituting to calculate p

$p=\frac{710}{10}+8$

$p=79$

Equilibrium occurs when the price is $79, and the quantity is 710 units.

73. **a.** $x+y=2600$

b. $40x$

c. $60y$

d. $40x+60y=120,000$

e. $$\begin{cases} x+y=2600 & (Eq1) \\ 40x+60y=120,000 & (Eq2) \end{cases}$$

$$\begin{cases} -40x-40y=-104,000 & -40\times(Eq1) \\ 40x+60y=120,000 & (Eq2) \end{cases}$$

$20y=16,000$

$y=\frac{16,000}{20}=800$

Substituting to calculate x

$x+800=2600$

$x=1800$

The promoter needs to sell 1800 tickets at $40 per ticket and 800 tickets at $60 per ticket.

74. a. $x + y = 500,000$

b. $0.12x$

c. $0.15y$

d. $0.12x + 0.15y = 64,500$

e. $\begin{cases} x + y = 500,000 & (Eq1) \\ 0.12x + 0.15y = 64,500 & (Eq2) \end{cases}$

$\begin{cases} -0.12x - 0.12y = -60,000 & -0.12 \times (Eq1) \\ 0.12x + 0.15y = 64,500 & (Eq2) \end{cases}$

$0.03y = 4500$

$y = \dfrac{4500}{0.03} = 150,000$

Substituting to calculate x

$x + 150,000 = 500,000$

$x = 350,000$

Devote \$350,000 in the 12% investment and \$150,000 in the 15% investment.

Extended Application I

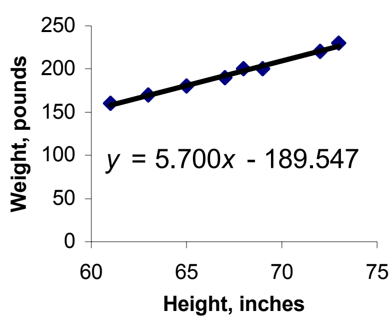
1. **a.** A person uses the table to determine his or her BMI by locating the entry in the table that corresponds to the person's height and weight. The entry in the table is the person's BMI.

b. If a person's BMI is 30 or higher, the person is considered obese and at risk for health problems.

c. **1.** Determine the heights and weights that produce a BMI of exactly 30 based on the table.

Height (inches)	Weight (pounds)
61	160
63	170
65	180
67	190
68	200
69	200
72	220
73	230

2.



A linear model is reasonable, but not exact.

3. See part *2* above.

4. See part *2* above. The scatter plot fits the data points well, but not perfectly.

5. Any data point that lies exactly along the line generated from the model will yield a BMI of 30. If a height is substituted into the model, the output weight would generate a BMI of 30. That weight or any higher weight for the given height would place a person at risk for health problems.