

## CHAPTER 2 Linear Models, Equations, and Inequalities

### Toolbox Exercises

1.  $3x = 6$

Division Property

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

$$x = 2$$

2.  $x - 7 = 11$

Addition Property

$$x - 7 = 11$$

$$x - 7 + 7 = 11 + 7$$

$$x = 18$$

3.  $x + 3 = 8$

Subtraction Property

$$x + 3 = 8$$

$$x + 3 - 3 = 8 - 3$$

$$x = 5$$

4.  $x - 5 = -2$

Addition Property

$$x - 5 = -2$$

$$x - 5 + 5 = -2 + 5$$

$$x = 3$$

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

Multiplication Property

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

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

$$x = 18$$

6.  $-5x = 10$

Division Property

$$\frac{-5x}{-5} = \frac{10}{-5}$$

$$x = -2$$

7.  $2x + 8 = -12$

Subtraction Property and division Property

$$2x + 8 = -12$$

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

$$2x = -20$$

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

$$x = -10$$

8.  $\frac{x}{4} - 3 = 5$

Addition Property and multiplication Property

$$\frac{x}{4} - 3 = 5$$

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

$$\frac{x}{4} = 8$$

$$4\left(\frac{x}{4}\right) = 4(8)$$

$$x = 32$$

9.  $4x - 3 = 6 + x$

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

$$3x - 3 = 6$$

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

$$3x = 9$$

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

$$x = 3$$

10.  $3x - 2 = 4 - 7x$

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

$$10x - 2 = 4$$

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

$$10x = 6$$

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

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

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

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

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

$$3x = 48$$

$$\frac{3x}{3} = \frac{48}{3}$$

$$x = 16$$

12.  $\frac{5x}{2} = -10$

$$2\left(\frac{5x}{2}\right) = 2(-10)$$

$$5x = -20$$

$$\frac{5x}{5} = \frac{-20}{5}$$

$$x = -4$$

13.

$$3(x - 5) = -2x - 5$$

$$3x - 15 = -2x - 5$$

$$3x + 2x - 15 = -2x + 2x - 5$$

$$5x - 15 = -5$$

$$5x - 15 + 15 = -5 + 15$$

$$5x = 10$$

$$\frac{5x}{5} = \frac{10}{5}$$

$$x = 2$$

14.

$$-2(3x - 1) = 4x - 8$$

$$-6x + 2 = 4x - 8$$

$$-6x - 4x + 2 = 4x - 4x - 8$$

$$-10x + 2 = -8$$

$$-10x + 2 - 2 = -8 - 2$$

$$-10x = -10$$

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

$$x = 1$$

15.

$$2x - 7 = -4\left(4x - \frac{1}{2}\right)$$

$$2x - 7 = -16x + 2$$

$$2x + 16x - 7 = -16x + 16x + 2$$

$$18x - 7 = 2$$

$$18x - 7 + 7 = 2 + 7$$

$$18x = 9$$

$$\frac{18x}{18} = \frac{9}{18}$$

$$x = \frac{1}{2}$$

16.

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

$$-4x + 12 = 9x - 1$$

$$-4x - 9x + 12 = 9x - 9x - 1$$

$$-13x + 12 = -1$$

$$-13x + 12 - 12 = -1 - 12$$

$$-13x = -13$$

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

$$x = 1$$

17.  $y = 2x$  and  $x + y = 12$

$$x + (2x) = 12$$

$$3x = 12$$

$$x = 4$$

18.  $y = 4x$  and  $x + y = 25$

$x + (4x) = 25$

$5x = 25$

$x = 5$

19.  $y = 3x$  and  $2x + 4y = 42$

$2x + 4(3x) = 42$

$2x + 12x = 42$

$14x = 42$

$x = 3$

20.  $y = 6x$  and  $3x + 2y = 75$

$3x + 2(6x) = 75$

$3x + 12x = 75$

$15x = 75$

$x = 5$

21.  $3x - 5x = 2x + 7$

$-2x = 2x + 7$

$-4x = 7$

$x = \frac{7}{-4}$

This is a conditional equation.

22.  $3(x+1) = 3x - 7$

$3x + 3 = 3x - 7$

$3 = -7$

This is a contradiction equation.

23.  $9x - 2(x - 5) = 3x + 10 + 4x$

$9x - 2x + 10 = 7x + 10$

$7x + 10 = 7x + 10$

This is an identity equation.

24.  $\frac{x}{2} - 5 = \frac{x}{4} + 2$

$2x - 20 = x + 8$

$x = 28$

This is a conditional equation.

25.  $5x + 1 > -5$

$5x > -6$

$x > -\frac{6}{5}$

26.  $1 - 3x \geq 7$

$-3x \geq 6$

$x \leq -2$

27.  $\frac{x}{4} > -3$

$x > -12$

28.  $\frac{x}{6} > -2$

$x > -12$

29.  $\frac{x}{4} - 2 > 5x$

$\frac{x}{4} > 5x + 2$

$x > 20x + 8$

$-19x > 8$

$x < -\frac{8}{19}$

**30.**  $\frac{x}{2} + 3 > 6x$

$x + 6 > 12x$

$-11x + 6 > 0$

$-11x > -6$

$x < \frac{6}{11}$

**31.**  $-3(x-5) < -4$

$-3x + 15 < -4$

$-3x < -19$

$x > \frac{19}{3}$

**32.**  $-\frac{1}{2}(x+4) < 6$

$-\frac{1}{2}x - 2 < 6$

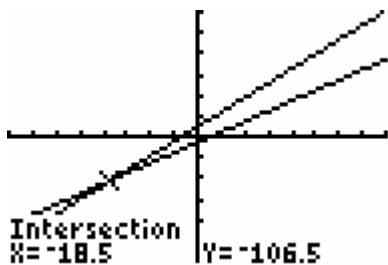
$-\frac{1}{2}x < 8$

$x > -16$

## Section 2.1 Skills Check

$$\begin{aligned}
 1. \quad & 5x - 14 = 23 + 7x \\
 & 5x - 7x - 14 = 23 + 7x - 7x \\
 & -2x - 14 = 23 \\
 & -2x - 14 + 14 = 23 + 14 \\
 & -2x = 37 \\
 & \frac{-2x}{-2} = \frac{37}{-2} \\
 & x = -\frac{37}{2} \\
 & x = -18.5
 \end{aligned}$$

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



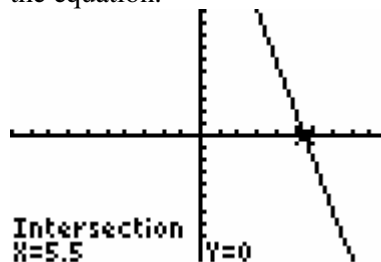
$[-40, 40]$  by  $[-300, 300]$

$$\begin{aligned}
 2. \quad & 3x - 2 = 7x - 24 \\
 & 3x - 7x - 2 = 7x - 7x - 24 \\
 & -4x - 2 = -24 \\
 & -4x = -22 \\
 & \frac{-4x}{-4} = \frac{-22}{-4} \\
 & x = \frac{-22}{-4} \\
 & x = \frac{11}{2} = 5.5
 \end{aligned}$$

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

$$\begin{aligned}
 & 3x - 2 = 7x - 24 \\
 & 3x - 7x - 2 + 24 = 0 \\
 & -4x + 22 = 0
 \end{aligned}$$

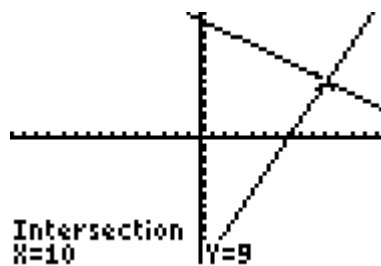
Graph  $y = -4x + 22$  and determine the  $x$ -intercept. The  $x$ -intercept is the solution to the equation.



$[-10, 10]$  by  $[-10, 10]$

$$\begin{aligned}
 3. \quad & 3(x - 7) = 19 - x \\
 & 3x - 21 = 19 - x \\
 & 3x + x - 21 = 19 - x + x \\
 & 4x - 21 = 19 \\
 & 4x - 21 + 21 = 19 + 21 \\
 & 4x = 40 \\
 & \frac{4x}{4} = \frac{40}{4} \\
 & x = 10
 \end{aligned}$$

Applying the intersections of graphs method yields:



$[-15, 15]$  by  $[-20, 20]$

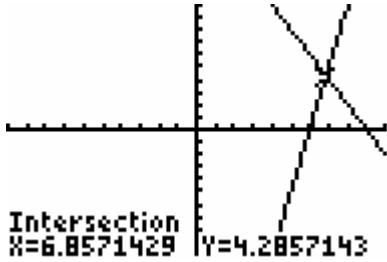
4.  $5(y - 6) = 18 - 2y$

$$5y - 30 = 18 - 2y$$

$$7y = 48$$

$$y = \frac{48}{7} \approx 6.8571429$$

Applying the intersections of graphs method yields:



$[-10, 10]$  by  $[-10, 10]$

Remember your calculator has solved for the  $x$ -value via the graph even though the original equation was written with the variable  $y$ .

5.

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

LCD: 12

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

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

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

$$-24x - 10 = 3$$

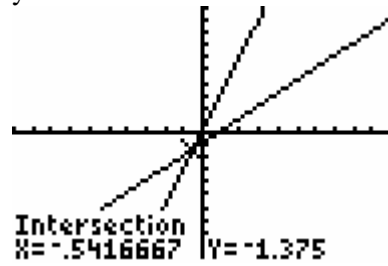
$$-24x - 10 + 10 = 3 + 10$$

$$-24x = 13$$

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

$$x = -\frac{13}{24} \approx -0.5416667$$

Applying the intersections of graphs method yields:



$[-10, 10]$  by  $[-10, 10]$

6.

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

LCD: 12

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

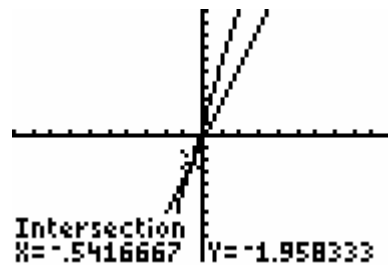
$$36x - 4 = 60x + 9$$

$$-24x - 4 = 9$$

$$-24x = 13$$

$$x = -\frac{13}{24} \approx -0.5416667$$

Applying the intersections of graphs method yields:



$[-10, 10]$  by  $[-10, 10]$

7.

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

LCD: 18

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

$$15(x-3) - 18x = 18 - 2x$$

$$15x - 45 - 18x = 18 - 2x$$

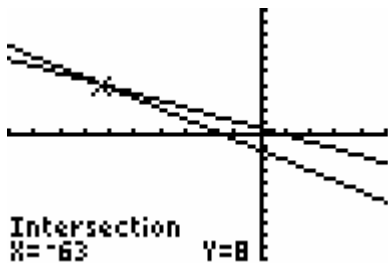
$$-3x - 45 = 18 - 2x$$

$$-1x - 45 = 18$$

$$-1x = 63$$

$$x = -63$$

Applying the intersections of graphs method yields:



[-100, 50] by [-20, 20]

8.

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

LCD: 15

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

$$3[4(y-2)] - 15y = 90 - 5y$$

$$12(y-2) - 15y = 90 - 5y$$

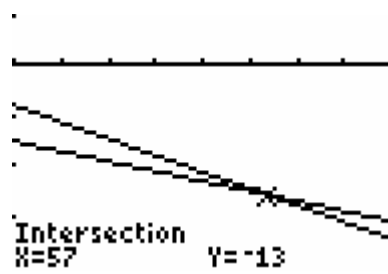
$$12y - 24 - 15y = 90 - 5y$$

$$-3y - 24 = 90 - 5y$$

$$2y = 114$$

$$y = 57$$

Applying the intersections of graphs method yields:



[30, 70] by [-20, 5]

Remember your calculator has solved for the  $x$ -value via the graph even though the original equation was written with the variable  $y$ .

9.  $5.92t = 1.78t - 4.14$

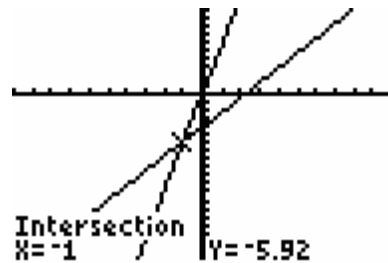
$$5.92t - 1.78t = -4.14$$

$$4.14t = -4.14$$

$$\frac{4.14t}{4.14} = \frac{-4.14}{4.14}$$

$$t = -1$$

Applying the intersections of graphs method yields:



[-10, 10] by [-20, 10]

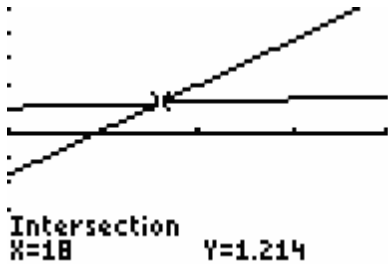
10.  $0.023x + 0.8 = 0.36x - 5.266$

$$-0.337x = -6.066$$

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

$$x = 18$$

Applying the intersections of graphs method yields:



[10, 30] by [-5, 5]

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

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

LCD = 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  $x$ .

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

LCD : 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  $x$ .

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

LCD : 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 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 for the function. Therefore, the solution to  $f(x) = 0$  is  $-0.5$ .

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

$$4x - 100 = 0$$

$$4x = 100$$

$$x = 25$$

The zero of the function, the  $x$ -intercept of the graph of the function, and the solution to  $f(x) = 0$  are all 25.

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

$$6x - 120 = 0$$

$$6x = 120$$

$$x = 20$$

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

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

$$330 + 40x = 0$$

$$40x = -330$$

$$x = -8.25$$

The zero of the function, the  $x$ -intercept of the graph of the function, and the solution to  $f(x) = 0$  are all  $-8.25$ .

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

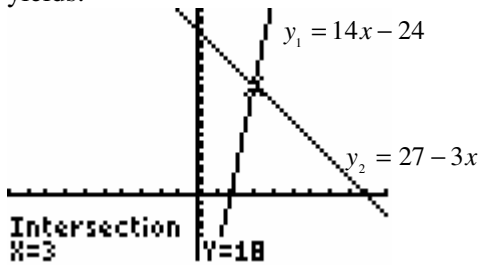
$$250 + 45x = 0$$

$$45x = -250$$

$$x = -\frac{50}{9}$$

The zero of the function, the  $x$ -intercept of the graph of the function, and the solution to  $f(x) = 0$  are all  $-50/9$ .

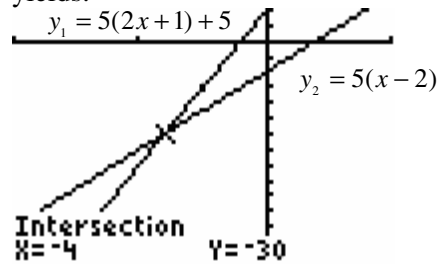
25. Applying the intersections of graphs method yields:



$[-10, 10]$  by  $[-10, 30]$

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

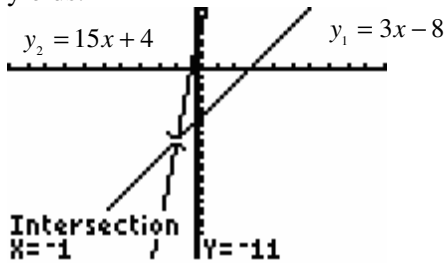
28. Applying the intersections of graphs method yields:



$[-10, 5]$  by  $[-70, 10]$

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

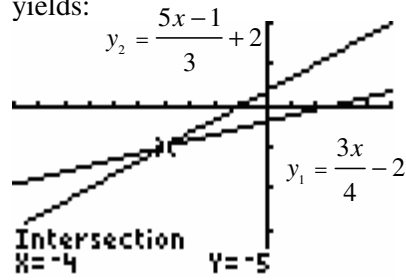
26. Applying the intersections of graphs method yields:



$[-10, 10]$  by  $[-30, 10]$

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

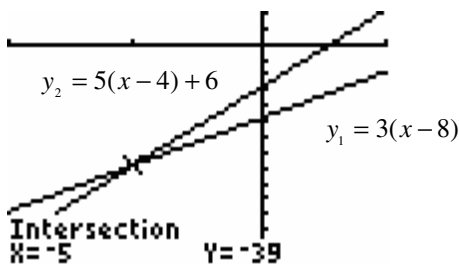
29. Applying the intersections of graphs method yields:



$[-10, 5]$  by  $[-20, 10]$

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

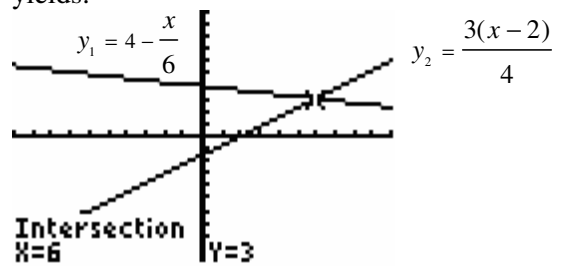
27. Applying the intersections of graphs method yields:



$[-10, 5]$  by  $[-70, 10]$

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

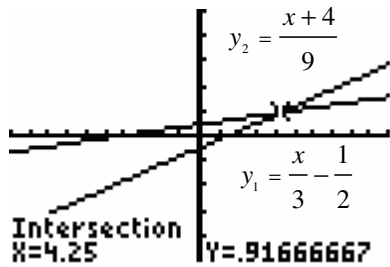
30. Applying the intersections of graphs method yields:



$[-10, 10]$  by  $[-10, 10]$

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

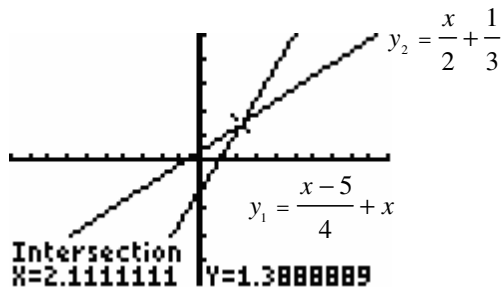
31. Applying the intersections of graphs method yields:



$[-10, 10]$  by  $[-5, 5]$

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

32. Applying the intersections of graphs method yields:



$[-10, 10]$  by  $[-5, 5]$

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

33.  $A = P(1 + rt)$

$$A = P + Prt$$

$$A - P = P - P + Prt$$

$$A - P = Prt$$

$$\frac{A - P}{P} = \frac{Prt}{P}$$

$$\frac{A - P}{P} = r \text{ or } r = \frac{A - P}{Pt}$$

- 34.

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

$$LCD : 3$$

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

$$3V = \pi r^2 h$$

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

$$\frac{3V}{\pi r^2} = h \text{ or } h = \frac{3V}{\pi r^2}$$

35.  $5F - 9C = 160$

$$5F - 9C + 9C = 160 + 9C$$

$$5F = 160 + 9C$$

$$\frac{5F}{5} = \frac{160 + 9C}{5}$$

$$F = \frac{9}{5}C + \frac{160}{5}$$

$$F = \frac{9}{5}C + 32$$

- 36.

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

$$LCD : 3$$

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

$$12(a - 2x) = 15x + c$$

$$12a - 24x = 15x + c$$

$$12a - 24x - 15x = 15x - 15x + c$$

$$12a - 39x = c$$

$$12a - 12a - 39x = c - 12a$$

$$-39x = c - 12a$$

$$x = \frac{c - 12a}{-39} \text{ or}$$

$$x = \left(\frac{-1}{-1}\right)\left(\frac{c - 12a}{-39}\right) = \frac{12a - c}{39}$$

37.

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

LCD: 2

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

$$P + 2A = 10m - 4n$$

$$P + 2A - 10m = 10m - 4n - 10m$$

$$\frac{P + 2A - 10m}{-4} = \frac{-4n}{-4}$$

$$\frac{P + 2A - 10m}{-4} = n$$

$$n = \frac{P}{-4} + \frac{2A}{-4} - \frac{10m}{-4}$$

$$n = \frac{5m}{2} - \frac{P}{4} - \frac{A}{2}$$

38.  $y - y_1 = m(x - x_1)$

$$y - y_1 = mx - mx_1$$

$$y - y_1 + mx_1 = mx - mx_1 + mx_1$$

$$\frac{y - y_1 + mx_1}{m} = \frac{mx}{m}$$

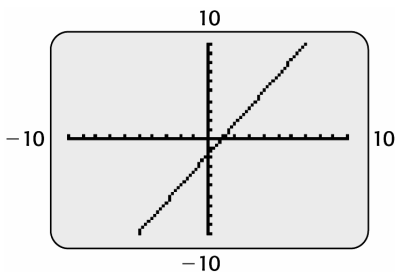
$$x = \frac{y - y_1 + mx_1}{m}$$

39.  $5x - 3y = 5$

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

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

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

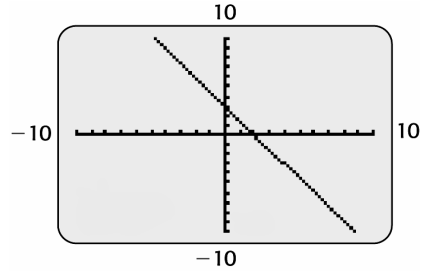


40.  $3x + 2y = 6$

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

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

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



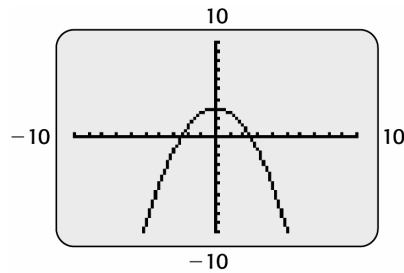
41.  $x^2 + 2y = 6$

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

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

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

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

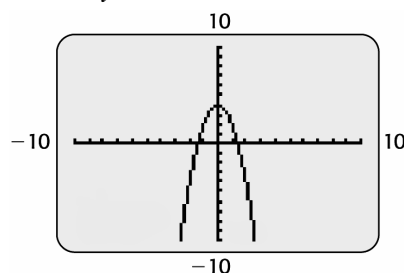


42.  $4x^2 + 2y = 8$

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

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

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



## Section 2.1 Exercises

43. 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.

44. Let
- $C = 20$
- and solve for
- $F$
- .

$$5F - 9C = 160$$

$$5F - 9(20) = 160$$

$$5F - 180 = 160$$

$$5F = 340$$

$$F = \frac{340}{5} = 68$$

$68^\circ$  Fahrenheit equals  $20^\circ$  Celsius.

- 45.
- $S = P(1 + rt)$

$$9000 = P(1 + (0.10)(5))$$

$$9000 = P(1 + 0.50)$$

$$9000 = 1.5P$$

$$P = \frac{9000}{1.5} = 6000$$

\$6000 must be invested as the principal.

- 46.
- $I = t - 0.55(1 - h)(t - 58)$

$$79 = 80 - 0.55(1 - h)(80 - 58)$$

$$79 = 80 - 0.55(1 - h)(22)$$

$$79 = 80 - 12.1(1 - h)$$

$$79 = 80 - 12.1 + 12.1h$$

$$79 = 67.9 + 12.1h$$

$$12.1h = 11.1$$

$$h = \frac{11.1}{12.1} =$$

$$h = 0.9173553719 \approx 0.92$$

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

- 47.
- $M = 0.819W - 3.214$

$$41.52 = 0.819W - 3.214$$

$$0.819W = 44.734$$

$$W = \frac{44.734}{0.819} = 54.620$$

The median annual salary for whites is approximately \$54,620.

48. 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  $-40^\circ$ .

49. Let
- $B(x) = 20.95$
- , and calculate
- $x$
- .

$$20.95 = 95.793 - 1.871x$$

$$1.871x = 74.843$$

$$x = \frac{74.843}{1.871} = 40$$

In the year 2020, 40 years after 1980, the average monthly bill will be \$20.95.

- 50.** 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 ( $1970 + 26$ ). The average reading score was 259.4 in 1996.

- 51.** Let  $y = 7056$ , and solve for  $x$ .

$$7056 = -380.9x + 18,483$$

$$7056 - 18,483 = -380.9x$$

$$-11,427 = -380.9x$$

$$x = \frac{-11427}{-380.9}$$

$$x = 30$$

An  $x$ -value of 30 corresponds to the year 2010 ( $1980 + 30$ ). The number of banks was 7056 in 2010.

- 52. a.** Let  $P(x) = \$8000$ , and calculate  $x$ .

$$8000 = 20x - 4000$$

$$20x = 12000$$

$$x = \frac{12000}{20} = 600$$

Based on the model, producing and selling 600 specialty golf hats will result in a profit of \$8000.

**b.**  $20x - 4000 \geq 0$

$$20x \geq 4000$$

$$x \geq \frac{4000}{20} = 200$$

Based on the model, producing and selling 200 specialty golf hats will avoid a loss.

- 53.** Let  $F(x) = 29.44$ , and calculate  $x$ .

$$29.44 = -0.065x + 31.39$$

$$0.065x = 1.95$$

$$x = \frac{1.95}{0.065} = 30$$

In the year 2020 ( $1990 + 30$ ), the percent of world forest area land will be 29.44%.

- 54.** Let  $y = 5.8$ , and calculate  $x$ .

$$5.8 = -0.146x + 11.074$$

$$0.146x = 5.274$$

$$x = \frac{5.274}{0.146} = 36.123 \approx 36$$

In the year 2016 ( $1980 + 36$ ), the marriage rate per 1000 population will be 5.8.

- 55.** Note that  $p$  is in millions. A population of 320,000,000 corresponds to a  $p$ -value of 320. Let  $p = 320$  and solve for  $x$ .

$$320 = 2.6x + 177$$

$$320 - 177 = 2.6x$$

$$143 = 2.6x$$

$$x = \frac{143}{2.6}$$

$$x = 55$$

An  $x$ -value of 55 corresponds to the year 2015 ( $1960 + 55$ ). Based on the model, in

2015, the population is estimated to be 320,000,000.

- 56.** When the number of inmates is 1,787,000, then  $y = 1,787$ . Let  $y = 1,787$ , and calculate  $x$ .

$$1,787 = 76x + 115$$

$$1,787 - 115 = 76x$$

$$1672 = 76x$$

$$x = \frac{1672}{76} = 22$$

An  $x$ -value of 22 corresponds to the year 2012 (1990 + 22). The number of inmates is estimated to be 1,787,000 in 2012.

- 57.** Let  $T(x) = 133,325$ , and calculate  $x$ .

$$133,325 = 16,665x - 116,650$$

$$16,665x = 249,975$$

$$x = \frac{249,975}{16,665} = 15$$

In the year 2015 (2000 + 15), the number of tweets will be 133,325 thousand.

- 58.** Let  $p = 12.7$ , and solve for  $x$ .

$$30(12.7) - 19x = 1$$

$$381 - 19x = 1$$

$$-19x = -380$$

$$x = \frac{-380}{-19}$$

$$x = 20$$

In the year 2010 (1990 + 20), the percent using marijuana daily was 12.7%.

- 59.** Let  $y = 14.8$ , and solve for  $x$ .

$$14.8 = 0.876x + 6.084$$

$$14.8 - 6.084 = 0.876x$$

$$8.716 = 0.876x$$

$$x = \frac{8.716}{0.876}$$

$$x = 9.94977 \approx 10$$

An  $x$ -value of 10 corresponds to the year 1990 (1980 + 10). The model shows that it was in 1990 that the number of Hispanics in the U.S. civilian population was 14.8 million.

- 60.** Let  $I(x) = 10,951$ , and solve for  $x$ .

$$10,951 = 386.17x + 524.32$$

$$10,951 - 524.32 = 386.17x$$

$$10,426.68 = 386.17x$$

$$x = \frac{10,426.68}{386.17}$$

$$x \approx 27$$

An  $x$ -value of 27 corresponds to the year 2007 (1980 + 27). Based on the model, U.S. personal income reached \$10,951 billion in 2007.

- 61. a.** Since the given function is described as linear, the increase of \$2.68 billion dollars between the years 2002 and 2003 represents the rate of change per year, or the slope of the function. Using the point-slope formula to determine the equation gives the following, where  $x = 3$ , the number of years since 2000 (2003-2000), and  $y = \$15.15$ , the expenditure in that year.

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

$$y - 15.15 = 2.68(x - 3)$$

$$y - 15.15 = 2.68x - 8.04$$

$$y = 2.68x + 7.11$$

- b. Let  $y = 60$ , and solve for  $x$ .

$$60 = 2.68x + 7.11$$

$$52.89 = 2.68x$$

$$x = \frac{52.89}{2.68} = 19.735 \approx 20$$

Since  $x = 20$  and  $x$  is the number of years after 2000, the year in which expenditures are expected to exceed 60 billion dollars is 2020.

62. If the number of customers is 311,700,000, then the value of  $S(x)$  is 311.70. Let  $S(x) = 311.70$ , and solve for  $x$ .

$$311.70 = 21x + 101.7$$

$$311.70 - 101.7 = 21x$$

$$210 = 21x$$

$$x = \frac{210}{21} = 10$$

An  $x$ -value of 10 corresponds to the year 2005 ( $1995 + 10$ ). The model indicates that there were 311.7 million subscribers in 2005.

63. Let  $x$  represent the score on the fifth exam.

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

$$\text{LCD: } 5$$

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

$$450 = 353 + x$$

$$x = 97$$

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

64. 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

$$\text{is } \frac{2x + 86 + 96}{4}.$$

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

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

$$\text{LCD: } 4$$

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

$$2x + 86 + 96 = 360$$

$$2x + 182 = 360$$

$$2x = 178$$

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

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

65. 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.

66. 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.



**67. Commission Reduction**

$$\begin{aligned}
 &= (20\%)(50,000) \\
 &= 10,000 \\
 \text{New Commission} \\
 &= 50,000 - 10,000 \\
 &= 40,000
 \end{aligned}$$

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.

Let  $x$  represent the percent increase from the second year.

$$\begin{aligned}
 40,000x &= 10,000 \\
 x &= 0.25 = 25\%
 \end{aligned}$$

**68. Salary Reduction**

$$\begin{aligned}
 &= (5\%)(100,000) \\
 &= 5000 \\
 \text{New Salary} \\
 &= 100,000 - 5000 \\
 &= 95,000
 \end{aligned}$$

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.

$$\begin{aligned}
 95,000x &= 9500 \\
 x &= \frac{9500}{95,000} = 0.10 = 10\%
 \end{aligned}$$

**69. Total cost = Original price + Sales tax**

Let  $x$  = original price.

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

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

$$29,998 = 1.06x$$

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

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

**70. 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.

**71.  $A = P + Prt$** 

$$A - P = P - P + Prt$$

$$A - P = Prt$$

$$\frac{A - P}{Pr} = \frac{Prt}{Pr}$$

$$\frac{A - P}{Pr} = t \text{ or } t = \frac{A - P}{Pr}$$

**72.  $A = P(1 + rt)$** 

$$\frac{A}{1 + rt} = P$$

73.

$$A = P(1 + rt)$$

$$A = P + Prt$$

$$A - P = P - P + Prt$$

$$A - P = Prt$$

$$\frac{A - P}{Pt} = \frac{Prt}{Pt}$$

$$\frac{A - P}{Pt} = r$$

$$\frac{3200 - 2000}{2000(6)} = r$$

$$\frac{1200}{12000} = \frac{1}{10} = r$$

$$r = .1 = 10\%$$

74.  $A = P(1 + rt)$ 

$$\frac{A}{1 + rt} = P$$

$$\frac{5888}{1 + .07(12)} = P$$

$$P = \$3200$$

75.  $\frac{I_1}{r_1} = \frac{I_2}{r_2}$ 

$$\frac{920}{.12} = \frac{x}{.08}$$

$$x = \frac{920(.08)}{.12} = \$613.33$$

76.  $\frac{I_1}{t_1} = \frac{I_2}{t_2}$ 

$$\frac{4903.65}{5} = \frac{7845.84}{x}$$

$$x = \frac{7845.84(5)}{4903.65} = 8 \text{ years}$$

77. Yes, the circumference of a circle varies directly with the radius of a circle since the relationship fits the direct variation format of  $y = kx$ , or in the case of a circle,  $C = 2\pi r$ , where the constant of variation is  $2\pi$ .

78. Since  $y = kx$  is the direct variation format, let  $y = H$  (heat) and  $x = A$  (amount of protein).

$$H = kA$$

$$32 = k(1), \text{ so } k = 32$$

$$\text{Then } H = 32A$$

$$180 = 32A$$

$$A = 5.625$$

Thus the amount of proteins to be burned to produce 180 calories is 5.625 grams.

79. a. Since  $y = kx$  is the direct variation format, let  $y = B$  (BMI) and  $x = w$  (weight of person in kilograms).

$$B = kw$$

$$20 = k(45), \text{ so } k = \frac{4}{9}$$

Thus the constant of variation is  $4/9$ .

b. Then  $32 = \frac{4}{9}A$

$$\frac{9}{4}(32) = A$$

$$A = 72$$

The woman would weigh 72 kilograms.

80. Since  $y = kx$  is the direct variation format, let  $y = C$  (cost of land) and  $x = S$  (size of land).

$$C = kS$$

$$172,800 = k(2500), \text{ so } k = 69.12$$

$$\text{Then } C = 69.12(5500)$$

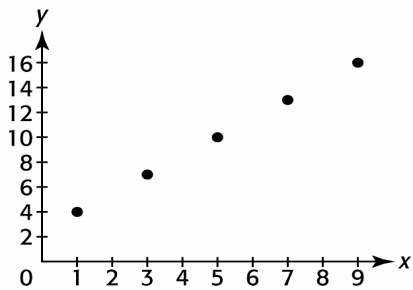
$$C = 380,160$$

Thus the cost of a piece of land that is 5500 square feet would be \$380,160.

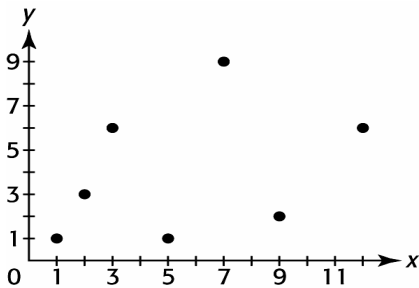
**Section 2.2 Skills Check**

1. No. The data points do not lie close to a straight line.
2. Yes. The data points lie approximately in a straight line.
3. Can be modeled approximately since not all points lie exactly on a line.
4. Can be modeled exactly since all points line up with a straight edge.

5.

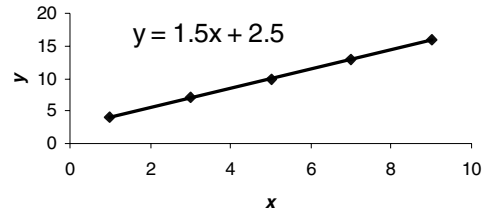


6.

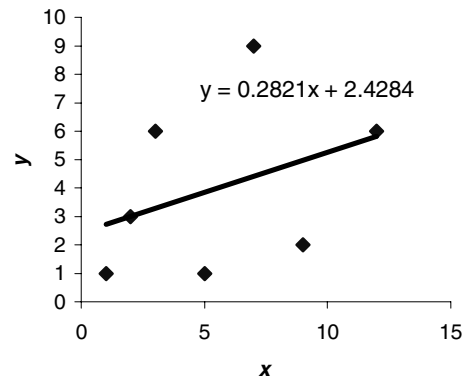


7. Exactly. The first differences of the outputs are constantly three.
8. No. The first differences are not constant. Also, a line will not connect perfectly the points on the scatter plot.

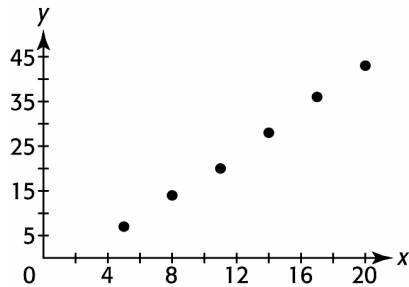
9. Using a spreadsheet program yields



10. Using a spreadsheet program yields

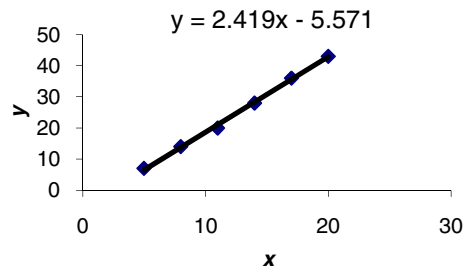


11.



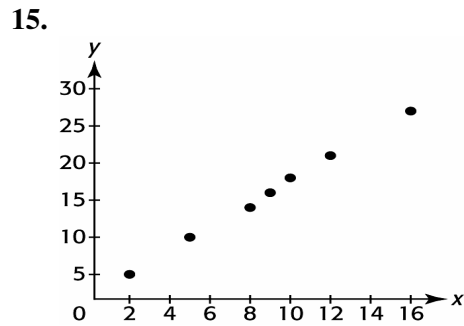
12. Yes. The points appear to lie approximately along a line.

13. Using a spreadsheet program yields

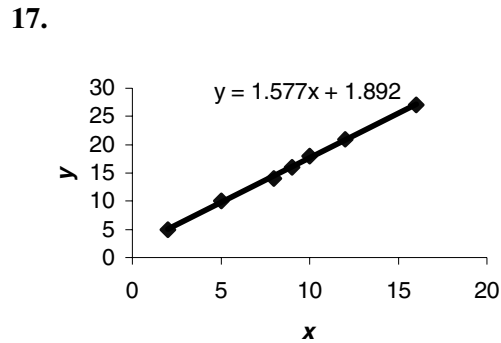


14.  $f(3) = 2.419(3) - 5.571$   
 $= 7.257 - 5.571$   
 $= 1.686 \approx 1.7$

$f(5) = 2.419(5) - 5.571$   
 $= 12.095 - 5.571$   
 $= 6.524 \approx 6.5$

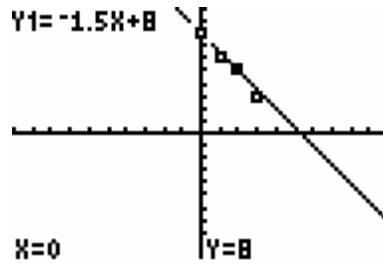
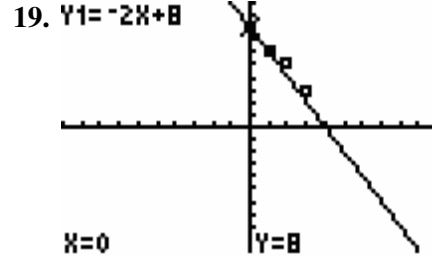


16. Yes. The points appear to lie approximately along a line.

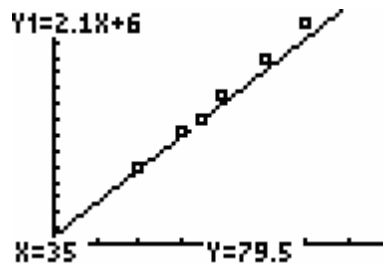
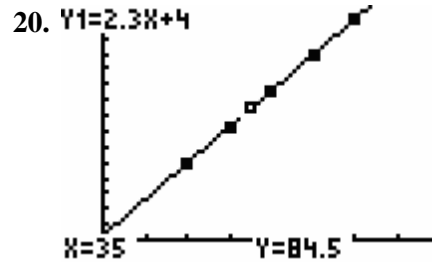


18.  $f(3) = 1.577(3) + 1.892$   
 $= 4.731 + 1.892$   
 $= 6.623 \approx 6.6$

$f(5) = 1.577(5) + 1.892$   
 $= 7.885 + 1.892$   
 $= 9.777 \approx 9.8$



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



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

- 21. a.** Exactly linear. The first differences are constant.
- b.** Nonlinear. The first differences vary, but don't grow continuously.
- c.** Approximately linear. The first differences increase continuously.
- 22.** The difference between inputs is not constant. The inputs are not equally spaced.

**Section 2.2 Exercises**

- 23. 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 better.
- 24. a.** Discrete. There are gaps between the years.
- 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.
- 25.** This data cannot be modeled exactly by a linear function since the increases from one bar top to the next are not constant.
- 26. a.** Yes. There is a one unit gap between the years and a constant 60 unit gap in future values.
- b.**  $S = f(t) = 60t + 1000$ , where 60 is the constant rate of change and (0, 1000) is the y-intercept.
- c.** For  $t = 7$ ,  $S(7) = 60(7) + 1000 = 1420$ . Thus the future value of this investment at the end of the 7<sup>th</sup> year is \$1420. This is an extrapolation since the result is beyond the original table values.
- d.** Discretely, since the interest payments occur only at the end of the years.
- 27. a.** Yes, the first differences are constant for uniform inputs.
- b.**  $T = 0.15x - 835$

- c. For  $x = 30,100$ ,  $T = \$3680.00$ , and for  $x = 30,300$ ,  $T = \$3710.00$ . These results agree with the values found in the table.
- d. For  $x = 30,125$ ,  $T = \$3683.75$ . Since 30,125 is within the given tables values, the result is an interpolation from the data.
- e. No, just tax due for income in the 15% tax bracket.

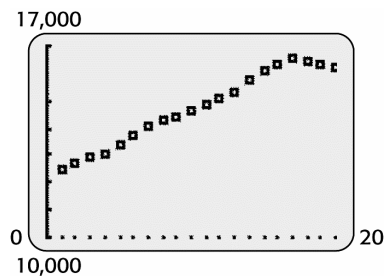
28. No, the first differences are not equal.

29. a. Using a spreadsheet program yields

$$y = 0.465x + 12.049$$

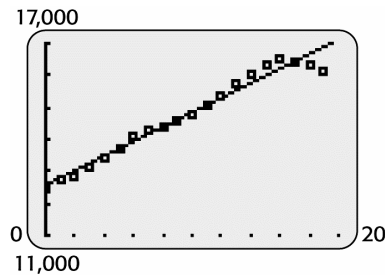
- b. With  $x = 18$ ,  $y = 20.419$  or approximately 20.4% of U.S. adults.
- c. With  $y = 25.05$ ,  $x = 27.979$ , or approximately 28 years after 2000, in the year 2028.

30. a. Using a spreadsheet program yields



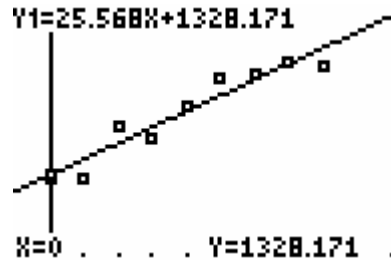
b.  $y = 227.070x + 12,560.686$

c.



The model and the scatterplot appear to be a fairly good fit.

31. a. Using a spreadsheet program yields



[0, 10] by [1200, 1600]

- b. Let  $x = 2010 - 2000 = 10$ , and solve for  $y$ .  
 $y = 25.568(10) + 1328.171$   
 $y = 1583.851 \approx 1583.9$

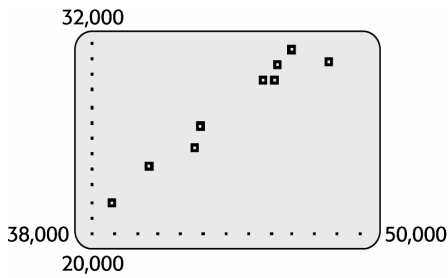
The model estimates the number of persons who took trips in 2010 to 1583.9 million, or 1.5839 billion.

c.

Let  $y = 1737.3$ , and solve for  $x$ .  
 $1737.3 = 25.568x + 1328.171$   
 $1737.3 - 1328.171 = 25.568x$   
 $25.568x = 409.129$   
 $x = \frac{409.129}{25.568} = 16.001 \approx 16$

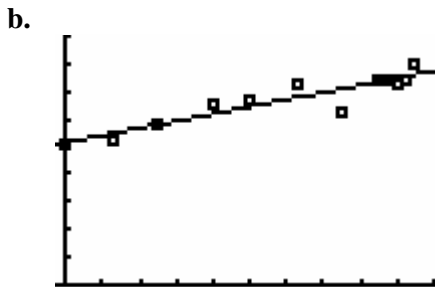
The model estimates that the year in which 1737.3 million trips were taken was 16 years after the year 2000, in 2016.

32. a. Using a spreadsheet program yields



- b.  $y = 1.052x - 18,691.28$
- c. The slope is 1.052, and for each increase of \$1.00 of median salary for whites, the black median salary will increase by \$1.05.

33. a.  $y = 0.323x + 25.759$

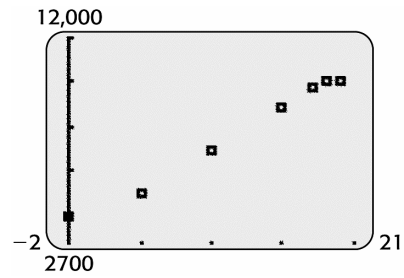


[0, 40] by [0, 45]  
Not close to an exact fit.

34. a.  $y = 4.471x + 38.887$

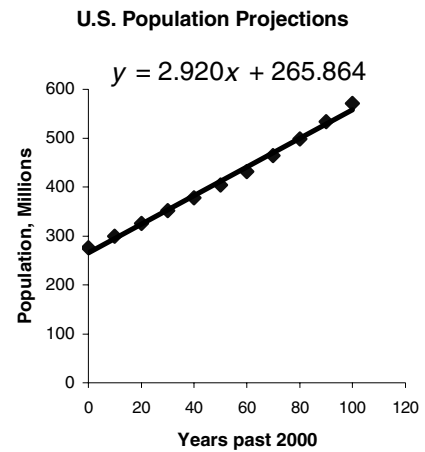
- b. When the CPI = 262.39,  $x = 50$ , which represents the year 2020, 50 years after 1970.

35. a. Using a spreadsheet program yields



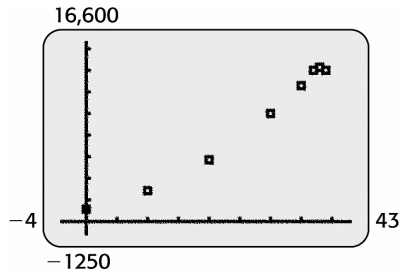
- b. Yes the fit appears to be a reasonable one for this data.
- c.  $y = 352.933x + 3533.995$
- d. The U.S. personal consumption for 2012 ( $x = 22$ ) is estimated to be \$11,298.521 billion.

36. a. Using a spreadsheet program yields



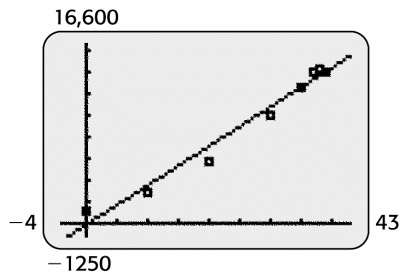
- b.  $f(65) \approx 455.7$ . The projected population in the year 2065 is 455.7 million.
- c. In 2080,  $x = 80$ . The population is predicted to be 499.5 million people, fairly close to the value in the table.

37. a. Using a spreadsheet program yields



b.  $y = 365.910x - 213.561$

c.



It appears to be a good fit.

38. a.  $y = -0.347x + 26.389$

b. Since 2012 is 22 years after 1990,  $x = 22$ . Solve for  $y = 18.75\%$ .

c. Let  $y = 16$ , and solve for  $x$ :  
 $16 = -0.347x + 26.389$   
 $-10.389 = -0.347x$   
 $x = 30$

Thus, when  $x = 30$  years after 1990, in the year 2020, the percent will be 16.

39. a. Using a spreadsheet program yields:

$$S = 122.914x - 477.438$$

b. The annual increase in the amount of online spending in this linear function is the slope of the line, \$122.914 million dollars.

c. To determine the percent increase in the amount of spending from 2009 to 2010, subtract the  $y$ -values for each year and divide by the  $y$ -value of the year 2009.

$$\frac{760 - 650}{650} = .1692 = 16.92\%$$

d. To determine the average rate of change of spending from 2006 to 2011, find the slope between the years.

$$\frac{857 - 259}{2011 - 2006} = \frac{598}{5} = 119.6$$

Thus, the average rate of change of spending from 2006 to 2011 is \$119.6 million dollars per year.

40. a. Using a spreadsheet program yields:

$$S = 1953.820x + 10,366.260$$

b. Since  $2002 - 1980 = 22$ ,

Let  $x = 22$ , and solve for  $y$ .

$$y = 1953.820(22) + 10,366.260$$

$$y = 53,350$$

Since 2002 is within the table of values for the years 1980 to 2007, this is interpolation.

c. Let  $y = 78,750$ , and solve for  $x$ :

$$78,750 = 1953.820x + 10,366.260$$

$$68,383.74 = 1953.820x$$

$$x = 35$$

Based on the model, the anticipated number of those imprisoned will be 78,750 in the year 2015, 35 years from 1980.

41. a.  $D = \frac{5}{11}W$

b. Fits exactly



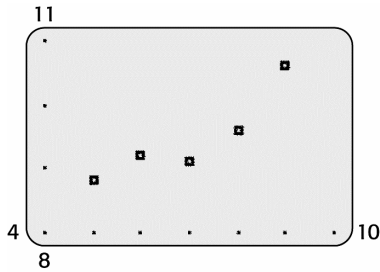
c.  $D = \frac{5}{11}(150) = 68.18 \text{ mg}$

d. Discretely.

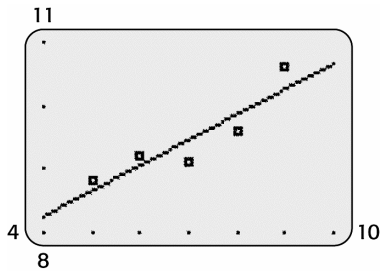
42. a.  $P = 0.822W + 4.062$

b. It is not a perfect fit.

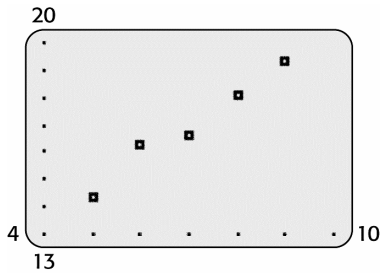
43. a.



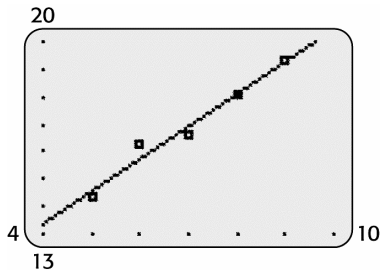
b.



c.

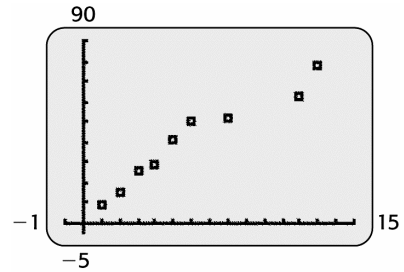


d.



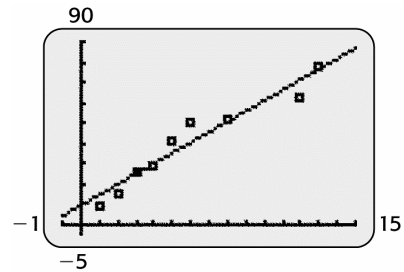
e. No, the U.S./Canada box office will not ever reach the International box office since the slope is less and thus rises slower.

44. a.



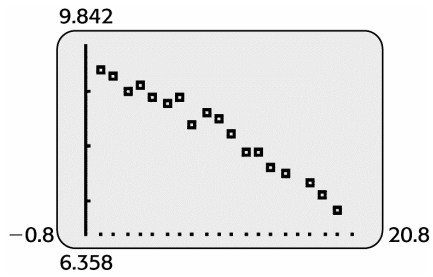
b.  $y = 5.167x + 9.189$

c.



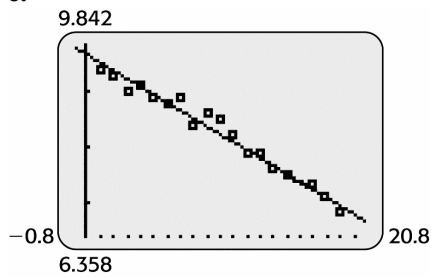
The model fits the data well.

45. a.



b.  $y = -0.139x + 9.633$

c.



The model fits the data well.

d.  $-0.139x + 9.633 = 6.5$   
 $-0.139x = 6.5 - 9.633 = -3.133$   
 $x = \frac{-3.133}{-0.139} = 22.5$

Thus, in the year 2013 (1990 + 23), the marriage rate is expected to be 6.5 per 1000 population.

## Section 2.3 Skills Check

1. To determine if an ordered pair is a solution of the system of equations, substitute each ordered pair into both equations.

- a. For the first equation, and

the point  $(2, 1)$

$$2x + 3y = -1$$

$$2(2) + 3(1) = 4 + 3 = 7$$

For the second equation, and

the point  $(2, 1)$

$$x - 4y = -6$$

$$(2) - 4(1) = 2 - 4 = -2$$

The point  $(2, 1)$  works in neither equation, thus is not a solution of the system.

- b. For the first equation, and

the point  $(-2, 1)$

$$2x + 3y = -1$$

$$2(-2) + 3(1) = -4 + 3 = -1$$

For the second equation, and

the point  $(-2, 1)$

$$x - 4y = -6$$

$$(-2) - 4(1) = -2 - 4 = -6$$

The point  $(-2, 1)$  works in both of the equations, thus is a solution of the system.

2. To determine if an ordered pair is a solution of the system of equations, substitute each ordered pair into both equations.

- a.

For the first equation, and

the point  $(\frac{3}{2}, -\frac{1}{2})$

$$4x - 2y = 7$$

$$4(\frac{3}{2}) - 2(-\frac{1}{2}) = 6 + 1 = 7$$

For the second equation, and

the point  $(\frac{3}{2}, -\frac{1}{2})$

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

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

The point  $(\frac{3}{2}, -\frac{1}{2})$  works in both of the equations, thus is a solution of the system.

- b.

For the first equation, and

the point  $(\frac{1}{2}, -\frac{3}{2})$

$$4x - 2y = 7$$

$$4(\frac{1}{2}) - 2(-\frac{3}{2}) = 2 + 3 = 5$$

For the second equation, and

the point  $(\frac{1}{2}, -\frac{3}{2})$

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

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

The point  $(\frac{1}{2}, -\frac{3}{2})$  works in only one of the equations, thus is not a solution of the system.

3. Applying the substitution method

$$y = 3x - 2 \text{ and } y = 3 - 2x$$

$$3 - 2x = 3x - 2$$

$$3 - 2x - 3x = 3x - 3x - 2$$

$$3 - 5x = -2$$

$$3 - 3 - 5x = -2 - 3$$

$$-5x = -5$$

$$x = 1$$

Substituting to find y

$$y = 3(1) - 2 = 1$$

(1,1) is the intersection point.

4. Applying the elimination method

$$\begin{cases} 3x + 2y = 5 & (Eq 1) \\ 5x - 3y = 21 & (Eq 2) \end{cases}$$

$$\begin{cases} 9x + 6y = 15 & 3 \times (Eq 1) \\ 10x - 6y = 42 & 2 \times (Eq 2) \end{cases}$$

$$\begin{cases} 9x + 6y = 15 & 3 \times (Eq 1) \\ 10x - 6y = 42 & 2 \times (Eq 2) \end{cases}$$

$$\begin{cases} 9x + 6y = 15 & 3 \times (Eq 1) \\ 10x - 6y = 42 & 2 \times (Eq 2) \end{cases}$$

$$19x = 57$$

$$x = \frac{57}{19} = 3$$

Substituting to find y

$$3(3) + 2y = 5$$

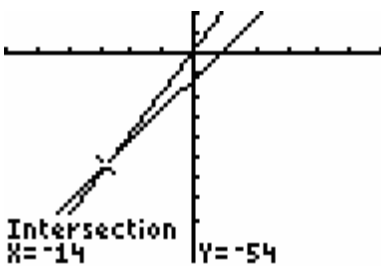
$$9 + 2y = 5$$

$$2y = -4$$

$$y = -2$$

(3,-2) is the intersection point.

5. Applying the intersection of graphs method, for  $y = 3x - 12$  and  $y = 4x + 2$



[-30, 30] by [-100, 20]

The solution for #5 is  $(-14, -54)$ .

6. 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

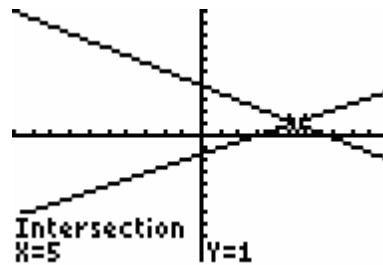
$$3x + 5y = 20$$

$$5y = -3x + 20$$

$$y = \frac{-3x + 20}{5}$$

$$y = -\frac{3}{5}x + 4$$

Applying the intersection of graphs method



[-10, 10] by [-10, 10]

The solution is (5,1).

7. Solving the equations for y

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

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

$$y = \frac{-4x - 4}{-3}$$

$$y = \frac{4}{3}x + \frac{4}{3}$$

and

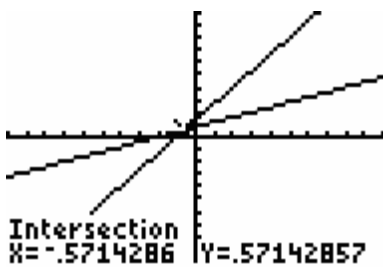
$$2x - 5y = -4$$

$$-5y = -2x - 4$$

$$y = \frac{-2x - 4}{-5}$$

$$y = \frac{2}{5}x + \frac{4}{5}$$

Applying the intersection of graphs method



[-10, 10] by [-10, 10]

The solution is (-0.5714, 0.5714) or

$$\left(-\frac{4}{7}, \frac{4}{7}\right).$$

8. Solving the equations for y

$$5x - 6y = 22$$

$$-6y = -5x + 22$$

$$y = \frac{-5x + 22}{-6}$$

$$y = \frac{5}{6}x - \frac{11}{3}$$

and

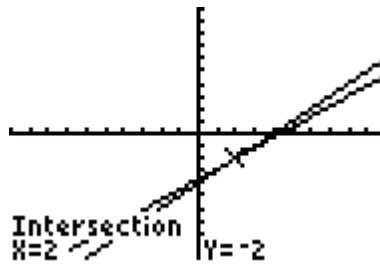
$$4x - 4y = 16$$

$$-4y = -4x + 16$$

$$y = \frac{-4x + 16}{-4}$$

$$y = x - 4$$

Applying the intersection of graphs method



[-10, 10] by [-10, 10]

The solution is (2, -2).

$$9. \begin{cases} 2x + 5y = 6 & (Eq 1) \\ x + 2.5y = 3 & (Eq 2) \end{cases}$$

$$\begin{cases} 2x + 5y = 6 & (Eq 1) \\ -2x - 5y = -6 & -2 \times (Eq 2) \end{cases}$$

$$0 = 0$$

There are infinitely many solutions to the system. The graphs of both equations represent the same line.

$$10. \begin{cases} 6x + 4y = 3 & (Eq\ 1) \\ 3x + 2y = 3 & (Eq\ 2) \end{cases}$$

$$\begin{cases} 6x + 4y = 3 & (Eq\ 1) \\ -6x - 4y = -6 & -2 \times (Eq\ 2) \end{cases}$$

$$0 = -3$$

There is no solution to the system. The graphs of the equations represent parallel lines.

11.

$$\begin{cases} x = 5y + 12 \\ 3x + 4y = -2 \end{cases}$$

Substituting the first equation 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  $(2, -2)$ .

12.

$$\begin{cases} 2x - 3y = 2 \\ y = 5x - 18 \end{cases}$$

Substituting the second equation 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  $(4, 2)$ .

$$13. \begin{cases} 2x - 3y = 5 \\ 5x + 4y = 1 \end{cases}$$

Solving the first equation for  $x$

$$2x - 3y = 5$$

$$2x = 3y + 5$$

$$x = \frac{3y + 5}{2}$$

Substituting into the second equation

$$5\left(\frac{3y + 5}{2}\right) + 4y = 1$$

$$2\left[5\left(\frac{3y + 5}{2}\right) + 4y\right] = 2[1]$$

$$15y + 25 + 8y = 2$$

$$23y + 25 = 2$$

$$23y = -23$$

$$y = -1$$

Substituting to find  $x$

$$2x - 3(-1) = 5$$

$$2x + 3 = 5$$

$$2x = 2$$

$$x = 1$$

The solution is  $(1, -1)$ .

$$14. \begin{cases} 4x - 5y = -17 \\ 3x + 2y = -7 \end{cases}$$

Solving the first equation for  $x$

$$4x - 5y = -17$$

$$4x = 5y - 17$$

$$x = \frac{5y - 17}{4}$$

Substituting into the second equation

$$3\left(\frac{5y - 17}{4}\right) + 2y = -7$$

$$4\left[3\left(\frac{5y - 17}{4}\right) + 2y\right] = 4[-7]$$

$$15y - 51 + 8y = -28$$

$$23y - 51 = -28$$

$$23y = 23$$

$$y = 1$$

Substituting to find  $x$

$$4x - 5(1) = -17$$

$$4x - 5 = -17$$

$$4x = -12$$

$$x = -3$$

The solution is  $(-3, 1)$ .

15.

$$\begin{cases} x + 3y = 5 & (Eq1) \\ 2x + 4y = 8 & (Eq2) \end{cases}$$

$$\begin{cases} x + 3y = 5 & (Eq1) \\ 2x + 4y = 8 & (Eq2) \end{cases}$$

$$\begin{cases} -2x - 6y = -10 & -2 \times (Eq 1) \\ 2x + 4y = 8 & (Eq 2) \end{cases}$$

$$\begin{cases} -2x - 6y = -10 & -2 \times (Eq 1) \\ 2x + 4y = 8 & (Eq 2) \end{cases}$$

$$-2y = -2$$

$$y = 1$$

Substituting to find  $x$

$$x + 3(1) = 5$$

$$x + 3 = 5$$

$$x = 2$$

The solution is  $(2, 1)$ .

16.

$$\begin{cases} 4x - 3y = -13 & (Eq1) \\ 5x + 6y = 13 & (Eq2) \end{cases}$$

$$\begin{cases} 8x - 6y = -26 & 2(Eq1) \\ 5x + 6y = 13 & (Eq2) \end{cases}$$

$$13x = -13$$

$$x = -1$$

Substituting to find  $x$ 

$$4(-1) - 3y = -13$$

$$-4 - 3y = -13$$

$$-3y = -9$$

$$y = 3$$

The solution is  $(-1, 3)$ .

17.

$$\begin{cases} 5x + 3y = 8 & (Eq1) \\ 2x + 4y = 8 & (Eq2) \end{cases}$$

$$\begin{cases} -10x - 6y = -16 & -2 \times (Eq1) \\ 10x + 20y = 40 & 5 \times (Eq2) \end{cases}$$

$$14y = 24$$

$$y = \frac{24}{14} = \frac{12}{7}$$

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  $\left(\frac{4}{7}, \frac{12}{7}\right)$ .

18.

$$\begin{cases} 3x + 3y = 5 & (Eq1) \\ 2x + 4y = 8 & (Eq2) \end{cases}$$

$$\begin{cases} -12x - 12y = -20 & -4 \times (Eq1) \\ 6x + 12y = 24 & 3 \times (Eq2) \end{cases}$$

$$-6x = 4$$

$$x = \frac{4}{-6} = -\frac{2}{3}$$

Substituting to find  $y$ 

$$3\left(-\frac{2}{3}\right) + 3y = 5$$

$$-2 + 3y = 5$$

$$3y = 7$$

$$y = \frac{7}{3}$$

The solution is  $\left(-\frac{2}{3}, \frac{7}{3}\right)$ .

19.

$$\begin{cases} 0.3x + 0.4y = 2.4 & (Eq1) \\ 5x - 3y = 11 & (Eq2) \end{cases}$$

$$\begin{cases} 9x + 12y = 72 & 30 \times (Eq1) \\ 20x - 12y = 44 & 4 \times (Eq2) \end{cases}$$

$$29x = 116$$

$$x = \frac{116}{29} = 4$$

Substituting to find  $y$ 

$$5(4) - 3y = 11$$

$$20 - 3y = 11$$

$$-3y = -9$$

$$y = 3$$

The solution is  $(4, 3)$ .



20.

$$\begin{cases} 8x - 4y = 0 & (Eq1) \\ 0.5x + 0.3y = 2.2 & (Eq2) \end{cases}$$

$$\begin{cases} 24x - 12y = 0 & 3 \times (Eq1) \\ 20x + 12y = 88 & 40 \times (Eq2) \end{cases}$$

$$44x = 88$$

$$x = 2$$

Substituting to find y

$$8(2) - 4y = 0$$

$$16 - 4y = 0$$

$$-4y = -16$$

$$y = 4$$

The solution is (2, 4).

21.

$$\begin{cases} 3x + 6y = 12 & (Eq1) \\ 4y - 8 = -2x & (Eq2) \end{cases}$$

$$\begin{cases} 3x + 6y = 12 & (Eq1) \\ 2x + 4y = 8 & (Eq2) \end{cases}$$

$$\begin{cases} -6x - 12y = -24 & -2 \times (Eq1) \\ 6x + 12y = 24 & 3 \times (Eq2) \end{cases}$$

$$0 = 0$$

Infinitely many solutions. The lines are the same. This is a dependent system.

22.

$$\begin{cases} 6y - 12 = 4x & (Eq1) \\ 10x - 15y = -30 & (Eq2) \end{cases}$$

$$\begin{cases} -4x + 6y = 12 & (Eq1) \\ 10x - 15y = -30 & (Eq2) \end{cases}$$

$$\begin{cases} -20x + 30y = 60 & 5 \times (Eq1) \\ 20x - 30y = -60 & 2 \times (Eq2) \end{cases}$$

$$0 = 0$$

Infinitely many solutions. The lines are the same. This is a dependent system.

23.

$$\begin{cases} 6x - 9y = 12 & (Eq1) \\ 3x - 4.5y = -6 & (Eq2) \end{cases}$$

$$\begin{cases} 6x - 9y = 12 & (Eq1) \\ -6x + 9y = 12 & -2 \times (Eq2) \end{cases}$$

$$\begin{cases} 6x - 9y = 12 & (Eq1) \\ -6x + 9y = 12 & -2 \times (Eq2) \end{cases}$$

$$0 = 24$$

$$0 = 24$$

No solution. Lines are parallel. This is an inconsistent system.

24.

$$\begin{cases} 4x - 8y = 5 & (Eq1) \\ 6x - 12y = 10 & (Eq2) \end{cases}$$

$$\begin{cases} 4x - 8y = 5 & (Eq1) \\ 6x - 12y = 10 & (Eq2) \end{cases}$$

$$\begin{cases} 12x - 24y = 15 & 3 \times (Eq1) \\ -12x + 24y = -20 & -2 \times (Eq2) \end{cases}$$

$$\begin{cases} 12x - 24y = 15 & 3 \times (Eq1) \\ -12x + 24y = -20 & -2 \times (Eq2) \end{cases}$$

$$0 = -5$$

No solution. Lines are parallel. This is an inconsistent system.

25.

$$\begin{cases} y = 3x - 2 \\ y = 5x - 6 \end{cases}$$

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).

$$26. \begin{cases} y = 8x - 6 \\ y = 14x - 12 \end{cases}$$

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  $(1, 2)$ .

27.

$$\begin{cases} 4x + 6y = 4 \\ x = 4y + 8 \end{cases}$$

Substituting the second  
equation into 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  $\left(\frac{32}{11}, -\frac{14}{11}\right)$ .

$$28. \begin{cases} y = 4x - 5 \\ 3x - 4y = 7 \end{cases}$$

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  $(1, -1)$ .

29.

$$\begin{cases} 2x - 5y = 16 & (Eq 1) \\ 6x - 8y = 34 & (Eq 2) \end{cases}$$

$$\begin{cases} 2x - 5y = 16 & (Eq 1) \\ 6x - 8y = 34 & (Eq 2) \end{cases}$$

$$\begin{cases} -6x + 15y = -48 & -3 \times (Eq 1) \\ 6x - 8y = 34 & (Eq 2) \end{cases}$$

$$\begin{cases} -6x + 15y = -48 & -3 \times (Eq 1) \\ 6x - 8y = 34 & (Eq 2) \end{cases}$$

$$7y = -14$$

$$y = -2$$

Substituting to find  $x$

$$2x - 5(-2) = 16$$

$$2x + 10 = 16$$

$$2x = 6$$

$$x = 3$$

The solution is  $(3, -2)$ .

30.

$$\begin{cases} 4x - y = 4 & (Eq1) \\ 6x + 3y = 15 & (Eq2) \end{cases}$$

$$\begin{cases} 12x - 3y = 12 & 3 \times (Eq 1) \\ 6x + 3y = 15 & (Eq 2) \end{cases}$$

$$18x = 27$$

$$x = \frac{27}{18} = \frac{3}{2}$$

Substituting to find  $y$ 

$$4\left(\frac{3}{2}\right) - y = 4$$

$$6 - y = 4$$

$$-y = -2$$

$$y = 2$$

The solution is  $\left(\frac{3}{2}, 2\right)$ .

31.

$$\begin{cases} 3x = 7y - 1 & (Eq1) \\ 4x + 3y = 11 & (Eq2) \end{cases}$$

$$\begin{cases} 3x - 7y = -1 & (Eq1) \\ 4x + 3y = 11 & (Eq2) \end{cases}$$

$$\begin{cases} -12x + 28y = 4 & -4 \times (Eq1) \\ 12x + 9y = 33 & 3 \times (Eq2) \end{cases}$$

$$37y = 37$$

$$y = \frac{37}{37} = 1$$

Substituting to find  $x$ 

$$3x - 7(1) = -1$$

$$3x - 7 = -1$$

$$3x = 6$$

$$x = 2$$

The solution is  $(2, 1)$ .

32.

$$\begin{cases} 5x = 12 + 3y & (Eq1) \\ 3x - 5y = 8 & (Eq2) \end{cases}$$

$$\begin{cases} 5x - 3y = 12 & (Eq1) \\ 3x - 5y = 8 & (Eq2) \end{cases}$$

$$\begin{cases} -15x + 9y = -36 & -3 \times (Eq1) \\ 15x - 25y = 40 & 5 \times (Eq2) \end{cases}$$

$$-16y = 4$$

$$y = \frac{4}{-16} = -\frac{1}{4}$$

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  $\left(\frac{9}{4}, -\frac{1}{4}\right)$ .

$$33. \begin{cases} 4x - 3y = 9 & (Eq1) \\ 8x - 6y = 16 & (Eq2) \end{cases}$$

$$\begin{cases} -8x + 6y = -18 & -2 \times (Eq 1) \\ 8x - 6y = 16 & (Eq 2) \end{cases}$$

$$0 = -2$$

No solution. Lines are parallel.

$$34. \begin{cases} 5x - 4y = 8 & (Eq 1) \\ -15x + 12y = -12 & (Eq 2) \end{cases}$$

$$\begin{cases} 15x - 12y = 24 & 3 \times (Eq 1) \\ -15x + 12y = -12 & (Eq 2) \end{cases}$$

$$0 = 12$$

No solution. Lines are parallel.

## Section 2.3 Exercises

35.  $R = C$

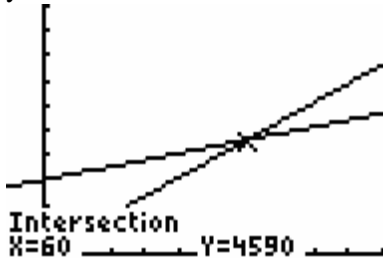
$$76.50x = 2970 + 27x$$

$$49.50x = 2970$$

$$x = \frac{2970}{49.50}$$

$$x = 60$$

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.

36.  $R = C$

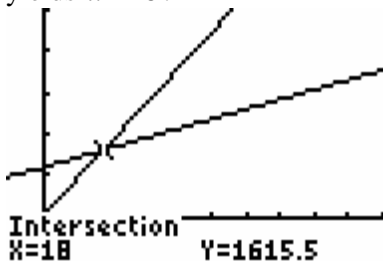
$$89.75x = 23.50x + 1192.50$$

$$66.25x = 1192.50$$

$$x = \frac{1192.50}{66.25}$$

$$x = 18$$

Applying the intersections of graphs method yields  $x = 18$ .



$[-10, 100]$  by  $[-1000, 5000]$

Break-even occurs when the number of units produced and sold is 18.

37.  $R = C$

$$15.80x = 8593.20 + 3.20x$$

$$12.60x = 8593.20$$

$$x = \frac{8593.20}{12.60}$$

$$x = 682$$

Break-even occurs when the number of units produced and sold is 682.

38.  $R = C$

$$136.50x = 9661.60 + 43.60x$$

$$92.90x = 9661.60$$

$$x = \frac{9661.60}{92.90}$$

$$x = 104$$

Break-even occurs when the number of units produced and sold is 104.

39. a.

$$\begin{cases} p + 2q = 320 & (Eq 1) \\ p - 8q = 20 & (Eq 2) \end{cases}$$

$$\begin{cases} 4p + 8q = 1280 & 4 \times (Eq 1) \\ p - 8q = 20 & (Eq 2) \end{cases}$$

$$\begin{cases} 4p + 8q = 1280 & \\ p - 8q = 20 & (Eq 2) \end{cases}$$

$$5p = 1300$$

$$p = 260$$

$$p = \frac{1300}{5} = 260$$

The equilibrium price is \$260.

b. Substituting to find  $q$ 

$$260 - 8q = 20$$

$$-8q = -240$$

$$q = \frac{-240}{-8} = 30$$

The equilibrium quantity occurs when 30 units are demanded and supplied.

**40. a.**Let  $p = 60$  and solve for  $q$ .

Supply function

$$60 = 5q + 20$$

$$5q = 40$$

$$q = 8$$

Demand function

$$60 = 128 - 4q$$

$$-4q = -68$$

$$q = \frac{-68}{-4} = 17$$

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,

$$5q + 20 = 128 - 4q$$

$$9q + 20 = 128$$

$$9q = 108$$

$$q = \frac{108}{9} = 12$$

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.

**41. a.** For the drug Concerta, let

$$x_1 = 0, y_1 = 2.4, \text{ and } x_2 = 11, y_2 = 10.$$

$$\text{Then, } \frac{y_2 - y_1}{x_2 - x_1} = \frac{10 - 2.4}{11 - 0} = 0.69$$

Since  $x_1 = 0$ ,  $y_1$  is the  $y$ -intercept.

Thus the equation is  $y = 0.69x + 2.4$ , representing the market share for Concerta as a linear function of time.

**b.** For the drug Ritalin, let

$$x_1 = 0, y_1 = 7.7, \text{ and } x_2 = 11, y_2 = 6.9.$$

$$\text{Then, } \frac{y_2 - y_1}{x_2 - x_1} = \frac{6.9 - 7.7}{11 - 0} = -0.073$$

Since  $x_1 = 0$ ,  $y_1$  is the  $y$ -intercept.

Thus the equation is  $y = -0.073x + 7.7$ , representing the market share for Ritalin as a linear function of time.

**c.** To determine the number of weeks past the release date when the two market shares are equal, set the two linear equations equal, and solve for  $x$ . Thus,

$$0.69x + 2.4 = -0.073x + 7.7$$

$$0.763x = 5.3$$

$$x = 6.946 \approx 7 \text{ weeks}$$

**42.** Equilibrium occurs when the demand equals the supply,

$$50.50 + .80q = 400 - .70q$$

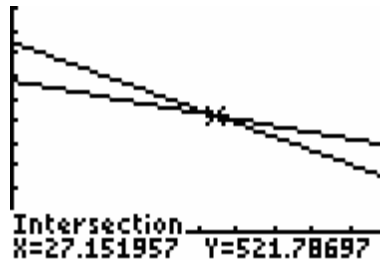
$$1.50q = 349.50$$

$$q = 233$$

Substituting to calculate  $p$ 

$$p = 50.50 + .80(233) = \$236.90$$

When the price is \$236.90, 233 units are produced and sold. This level of production and price represents equilibrium.

**43. a.** Applying the intersection of graphs method

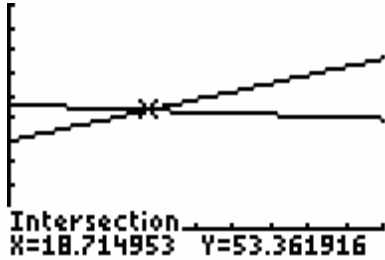
$$[0, 50] \text{ by } [-100, 1000]$$

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 were on active duty in each service branch.

44. Applying the intersection of graphs method



$[0, 50]$  by  $[-10, 100]$

The solution is  $(18.715, 53.362)$ . In 1979, the percent of male students enrolled in college within 12 months of high school graduation equaled the percent of female students enrolled in college within 12 months of high school graduation.

- 45.  $y_H = 0.224x + 9.0$  (the % of Hispanics)  
 $y_B = 0.057x + 12.3$  (the % of blacks)

Setting the first equation equal to the second equation, solve for  $x$ :

$$0.224x + 9.0 = 0.057x + 12.3$$

$$.167x = 3.3$$

$$x = \frac{3.3}{.167} = 19.76 \approx 20$$

Thus, 20 years after 1980, in the year 2000, the percent of Hispanics in the U.S. civilian non-institutional population equaled the percent of blacks.

46.  $B_1 = 0.6234W + 0.3785$

$$B_2 = 1.05W - 18.691$$

Setting the first equation equal to the second equation solve for  $x$ :

$$0.6234W + 0.3785 = 1.05W - 18.691$$

$$-0.4266W = -19.0695$$

$$W = \frac{-19.0695}{-0.4266} = \$44,701$$

Thus, the annual earning amount by whites that will give the same median annual earnings for blacks in both models is \$44,701.

47.

Let  $h$  = the 2011 revenue, and

let  $l$  = the 2008 revenue.

$$\begin{cases} h + 2l = 2144.9 & (Eq 1) \\ h - l = 135.5 & (Eq 2) \end{cases}$$

$$\begin{cases} h + 2l = 2144.9 & (Eq 1) \\ 2h - 2l = 271 & 2 \times (Eq 2) \end{cases}$$

$$\begin{cases} h + 2l = 2144.9 & (Eq 1) \\ 2h - 2l = 271 & 2 \times (Eq 2) \end{cases}$$

$$3h = 2415.9$$

$$h = \frac{2415.9}{3} = 805.3$$

Substituting to calculate  $l$

$$805.3 - l = 135.5$$

$$-l = -669.8$$

$$l = 669.8$$

The 2008 revenue is \$669.8 million, while the 2011 revenue is \$805.3 million.

48.

Let  $l$  = the low stock price, and let  $h$  = the high stock price.

$$\begin{cases} h + l = 83.5 & (\text{Eq 1}) \\ h - l = 21.88 & (\text{Eq 2}) \end{cases}$$

$$2h = 105.38$$

$$h = \frac{105.38}{2} = 52.69$$

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.

49. a.  $x + y = 2400$

b.  $30x$

c.  $45y$

d.  $30x + 45y = 84,000$

e.

$$\begin{cases} x + y = 2400 & (\text{Eq 1}) \\ 30x + 45y = 84,000 & (\text{Eq 2}) \end{cases}$$

$$\begin{cases} -30x - 30y = -72,000 & (\text{Eq 1}) \\ 30x + 45y = 84,000 & -30 \times (\text{Eq 2}) \end{cases}$$

$$15y = 12,000$$

$$y = \frac{12,000}{15} = 800$$

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.

50. a.  $x + y = 500,000$

b.  $10\%x$  or  $0.10x$

c.  $12\%y$  or  $0.12y$

d.  $0.10x + 0.12y = 53,000$

e.

$$\begin{cases} x + y = 500,000 & (\text{Eq 1}) \\ 0.10x + 0.12y = 53,000 & (\text{Eq 2}) \end{cases}$$

$$\begin{cases} -0.10x - 0.10y = -50,000 & -0.10 \times (\text{Eq 1}) \\ 0.10x + 0.12y = 53,000 & (\text{Eq 2}) \end{cases}$$

$$\begin{cases} -0.10x - 0.10y = -50,000 & -0.10 \times (\text{Eq 1}) \\ 0.10x + 0.12y = 53,000 & (\text{Eq 2}) \end{cases}$$

$$0.02y = 3000$$

$$y = \frac{3000}{0.02} = 150,000$$

Substituting to calculate  $x$

$$x + 150,000 = 500,000$$

$$x = 350,000$$

\$350,000 is invested in the 10% property, and \$150,000 is invested in the 12% property.

51. a.

Let  $x$  = the amount in the safer account, and let  $y$  = the amount in the riskier account.

$$\begin{cases} x + y = 100,000 & (\text{Eq 1}) \\ 0.08x + 0.12y = 9,000 & (\text{Eq 2}) \end{cases}$$

$$\begin{cases} 0.08x + 0.12y = 9,000 & (\text{Eq 2}) \\ -0.08x - 0.08y = -8,000 & -0.08 \times (\text{Eq 1}) \end{cases}$$

$$\begin{cases} -0.08x - 0.08y = -8,000 & -0.08 \times (\text{Eq 1}) \\ 0.08x + 0.12y = 9,000 & (\text{Eq 2}) \end{cases}$$

$$0.04y = 1000$$

$$y = \frac{1000}{0.04} = 25,000$$

Substituting to calculate  $x$

$$x + 25,000 = 100,000$$

$$x = 75,000$$

b. \$75,000 is invested in the 8% account, and \$25,000 is invested in the 12% account. Using two accounts minimizes investment risk.

**52. a.**

Let  $x$  = the amount in the safer fund, and  
let  $y$  = the amount in the riskier fund.

$$\begin{cases} x + y = 52,000 & (Eq\ 1) \\ 0.10x + 0.14y = 5,720 & (Eq\ 2) \end{cases}$$

$$\begin{cases} -0.10x - 0.10y = -5,200 & -0.10 \times (Eq\ 1) \\ 0.10x + 0.14y = 5,720 & (Eq\ 2) \end{cases}$$

$$0.04y = 520$$

$$y = \frac{520}{0.04} = 13,000$$

Substituting to calculate  $x$

$$x + 13,000 = 52,000$$

$$x = 39,000$$

Thus, \$39,000 is invested in the 10% fund,  
and \$13,000 is invested in the 14% fund.

**53.**

Let  $x$  = the amount in the money market fund,  
and let  $y$  = the amount in the mutual fund.

$$\begin{cases} x + y = 250,000 & (Eq\ 1) \\ 0.066x + 0.086y = .07(x + y) & (Eq\ 2) \end{cases}$$

$$66x + 86y = 70x + 70y \quad 1000 \times (Eq\ 2)$$

$$16y = 4x$$

$$4y = x$$

Then substituting  $4y$  for  $x$  in *Eq 1*, gives

$$4y + y = 250,000$$

$$5y = 250,000$$

$$y = 50,000$$

Substituting to calculate  $x$

$$x + 50,000 = 250,000$$

$$x = 200,000$$

Thus, \$200,000 is invested in the money  
market fund, and \$50,000 is invested in the  
mutual fund.

**54.**

Let  $x$  = the amount in the money market fund,  
and let  $y$  = the amount in the mutual fund.

$$\begin{cases} x + y = 300,000 & (Eq\ 1) \\ 0.062x + 0.092y = .076(x + y) & (Eq\ 2) \end{cases}$$

$$62x + 92y = 76x + 76y \quad 1000 \times (Eq\ 2)$$

$$16y = 14x$$

$$y = \frac{14}{16}x = \frac{7}{8}x$$

Then substituting  $\frac{7}{8}x$  for  $y$  in *Eq 1*, gives

$$x + \frac{7}{8}x = 300,000$$

$$8x + 7x = 2,400,000$$

$$15x = 2,400,000$$

$$x = 160,000$$

Substituting to calculate  $y$

$$y = \frac{7}{8}(160,000) = 140,000$$

Thus, \$160,000 is invested in the money  
market fund, and \$140,000 is invested in the  
mutual fund.

**55.**

Let  $x$  = the amount (cc's) of the 10% solution,  
and let  $y$  = the amount (cc's) of the 5% solution.

$$\begin{cases} x + y = 100 \text{ (cc's of the final solution)} & (Eq\ 1) \\ 0.10x + 0.05y = 0.08(100) & (Eq\ 2) \end{cases}$$

$$\begin{cases} 10x + 5y = 800 & 100 \times (Eq\ 2) \\ -5x - 5y = -500 & -5 \times (Eq\ 1) \end{cases}$$

Then using the elimination method

$$5x = 300$$

$$x = 60 \text{ cc's of the 10% solution}$$

Substituting to calculate  $y$

$$y = 40 \text{ cc's of the 5% solution}$$

Thus, 60 cc's of the 10% solution should be  
mixed with 40 cc's of the 5% solution to get  
100 cc's of the 8% solution.



56.

Let  $x$  = the amount (cc's) of the 16% solution,  
and let  $y$  = the amount (cc's) of the 6% solution.

$$\begin{cases} x + y = 200 & \text{(cc's of the final solution)} & (Eq\ 1) \\ 0.16x + 0.06y = 0.12(200) & & (Eq\ 2) \end{cases}$$

$$\begin{cases} 16x + 6y = 2400 & 100 \times (Eq\ 2) \\ -6x - 6y = -1200 & -5 \times (Eq\ 1) \end{cases}$$

Then using the elimination method

$$10x = 1200$$

$$x = 120 \text{ cc's of the 16\% solution}$$

Substituting to calculate  $y$

$$y = 80 \text{ cc's of the 6\% solution}$$

Thus, 120 cc's of the 16% solution should be mixed with 80 cc's of the 6% solution to get 200 cc's of the 12% solution.

57.

Let  $x$  = the number of glasses of milk,  
and let  $y$  = the number of 1/4-pound  
servings of meat.

Then the protein equation is:

$$8.5x + 22y = 69.5 \quad (Eq\ 1)$$

and the iron equation is:

$$0.1x + 3.4y = 7.1 \quad (Eq\ 2)$$

$$\begin{cases} 85x + 220y = 695 & 10 \times (Eq\ 1) \\ 1x + 34y = 71 & 10 \times (Eq\ 2) \end{cases}$$

$$-85x - 2890y = -6035 \quad -85 \times (Eq\ 2)$$

$$-2670y = -5340$$

$$y = \frac{-5340}{-2670} = 2$$

Substituting to calculate  $x$

$$8.5x + 22(2) = 69.5$$

$$8.5x + 44 = 69.5$$

$$8.5x = 25.5$$

$$x = \frac{25.5}{8.5} = 3$$

Thus, 3 glasses of milk and 2 servings of meat provide the desired quantities for the diet.

58.

Let  $x$  = the amount of substance A, and  
let  $y$  = the amount of substance B.

Nutrient equation:

$$6\%x + 10\%y = 100\%$$

$$\begin{cases} x + y = 14 & (Eq1) \\ 0.06x + 0.10y = 1 & (Eq2) \end{cases}$$

$$-0.06x - 0.06y = -0.84 \quad -0.06 \times (Eq1)$$

$$0.06x + 0.10y = 1 \quad (Eq2)$$

$$0.04y = 0.16$$

$$y = \frac{0.16}{0.04} = 4$$

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%.

59. To find when the percent of those enrolled equals that of those not enrolled, set the equations equal to each other and solve for  $x$ . Then find the percent by substituting into either one of the original equations.

$$-0.282x + 19.553 = -0.086x + 13.643$$

$$-0.196x = -5.91$$

$x = 30.153$ , the number of years after the year 2000, during the year 2031.

Substituting to calculate  $y$ :

$$y = -0.282(30.153) + 19.553$$

$$y = 11\%$$

It is estimated that in the year 2031, the percent of young adults aged 18 to 22 who use alcohol will be the same for those enrolled in college as for those not enrolled in college. That percent will be 11%.

60.

Let  $x$  = the amount of the 30% solution, and  
let  $y$  = the amount of the 15% solution.

$$x + y = 45$$

Medicine concentration:

$$30\%x + 15\%y = 20\%(45)$$

$$\begin{cases} x + y = 45 & (Eq1) \\ 0.30x + 0.15y = 9 & (Eq2) \end{cases}$$

$$-0.30x - 0.30y = -13.5 \quad -0.30 \times (Eq1)$$

$$0.30x + 0.15y = 9 \quad (Eq2)$$

$$-0.15y = -4.5$$

$$y = \frac{-4.5}{-0.15} = 30$$

Substituting to calculate  $x$

$$x + 30 = 45$$

$$x = 15$$

The nurse should mix 15 cc of the 30% solution with 30 cc of the 15% solution to obtain 45 cc of a 20% solution.

61.

L1	L2	L3	1
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  $p = -\frac{1}{2}q + 155$ .

$$\begin{aligned} &\text{LinReg} \\ &y = ax + b \\ &a = -.5 \\ &b = 155 \end{aligned}$$

- b. Supply function: Finding a linear model using  $L_3$  as input and  $L_1$  as output yields

$$p = \frac{1}{4}q + 50.$$

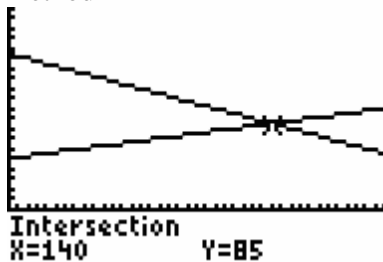
```
LinReg
y=ax+b
a=.25
b=50
```

- Supply function: Finding a linear model using  $L_3$  as input and  $L_1$  as output yields

$$p = \frac{1}{2}q + 0 \text{ or } p = \frac{1}{2}q.$$

```
LinReg
y=ax+b
a=.5
b=0
```

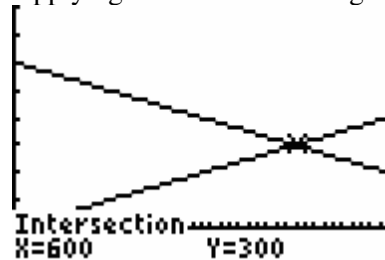
- c. Applying the intersection of graphs method



$[0, 200]$  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.

- 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

62.

L1	L2	L3	1
800	400	400	
400	200	800	
600	0	1200	
-----			
L1(1)=200			

- Demand function: Finding a linear model using  $L_3$  as input and  $L_2$  as output

$$\text{yields } p = -\frac{1}{2}q + 600.$$

```
LinReg
y=ax+b
a=-.5
b=600
```

63. Applying the intersection of graphs method



$[-5, 5]$  by  $[-5, 15]$

Although the lines do intersect, they intersect at a negative  $x$ -value which indicates they were equal prior to 1990. Since the problem calls for a time after the year 2000, there is no solution to the system.

**64.**  $20\%x + 5\%y = 15.5\%(x + y)$

$$0.20x + 0.05y = 0.155x + 0.155y$$

$$0.045x = 0.105y$$

$$\frac{0.045x}{0.105} = \frac{0.105y}{0.105}$$

$$y = \frac{3}{7}x$$

Therefore, the amount of  $y$  must equal  $\frac{3}{7}$  of the amount of  $x$ .

$$\text{If } x = 7, y = \frac{3}{7}(7) = 3.$$

The 5% concentration must be increased by 3 cc.

**65. 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.

**66.** 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 demand equation:

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

$$y - 350 = -\frac{1}{8}(x - 800)$$

$$y - 350 = -\frac{1}{8}x + 100$$

$$y = -\frac{1}{8}x + 450 \text{ or}$$

$$p = -\frac{1}{8}q + 450$$

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 supply equation:

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

$$y - 280 = \frac{3}{20}(x - 700)$$

$$y - 280 = \frac{3}{20}x - 105$$

$$y = \frac{3}{20}x + 175 \text{ or}$$

$$p = \frac{3}{20}q + 175$$

To find the quantity,  $q$ , that produces market equilibrium, set the equations equal.

$$-\frac{1}{8}q + 450 = \frac{3}{20}q + 175$$

LCD: 40

$$40\left(-\frac{1}{8}q + 450\right) = 40\left(\frac{3}{20}q + 175\right)$$

$$-5q + 18,000 = 6q + 7000$$

$$-11q = -11,000$$

$$q = \frac{-11,000}{-11} = 1000$$

To find the price,  $p$ , at market equilibrium, solve for  $p$ .

$$p = -\frac{1}{8}(1000) + 450 = 325$$

Thus, the market equilibrium point is (1000, 325). If the price per unit is \$325, both supply and demand will be 1000 units.

67. 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 demand equation:

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

$$y - 10 = \frac{-1}{10}(x - 900)$$

$$y - 10 = \frac{-1}{10}x + 90$$

$$y = \frac{-1}{10}x + 100 \text{ or}$$

$$p = \frac{-1}{10}q + 100$$

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 supply equation:

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

$$y - 30 = \frac{2}{70}(x - 700)$$

$$y - 30 = \frac{2}{70}x - 20$$

$$y = \frac{2}{70}x + 10 \text{ or}$$

$$p = \frac{2}{70}q + 10$$

To find the quantity,  $q$ , that produces market equilibrium, set the equations equal.

$$\frac{-1}{10}q + 100 = \frac{2}{70}q + 10$$

$$70\left(\frac{-1}{10}q + 100\right) = 70\left(\frac{2}{70}q + 10\right)$$

$$-7q + 7000 = 2q + 700$$

$$-9q = -6300$$

$$q = \frac{-6300}{-9} = 700$$

To find the price,  $p$ , at market equilibrium, solve for  $p$ .

$$p = \frac{2}{70}(700) + 10$$

$$p = 2(10) + 10$$

$$p = 30$$

700 units priced at \$30 represents the market equilibrium.

**Section 2.4 Skills Check**

1. Algebraically:

$$3x - 7 \leq 5 - x$$

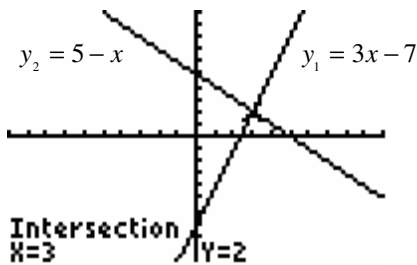
$$4x - 7 \leq 5$$

$$4x \leq 12$$

$$x \leq \frac{12}{4}$$

$$x \leq 3$$

Graphically:

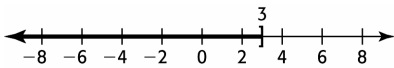


$[-10, 10]$  by  $[-10, 10]$

$3x - 7 \leq 5 - x$  implies that the solution region is  $x \leq 3$ .

The interval notation is  $(-\infty, 3]$ .

The graph of the solution is:



2. Algebraically:

$$2x + 6 < 4x + 5$$

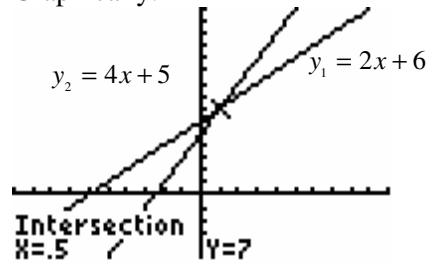
$$-2x + 6 < 5$$

$$-2x < -1$$

$$\frac{-2x}{-2} > \frac{-1}{-2} \quad (\text{Note the inequality sign switch})$$

$$x > \frac{1}{2}$$

Graphically:

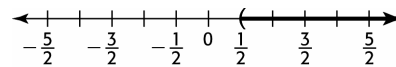


$[-5, 5]$  by  $[-5, 15]$

$2x + 6 < 4x + 5$  implies that the solution region is  $x > \frac{1}{2}$ .

The interval notation is  $(\frac{1}{2}, \infty)$ .

The graph of the solution is:



3. Algebraically:

$$4(3x - 2) \leq 5x - 9$$

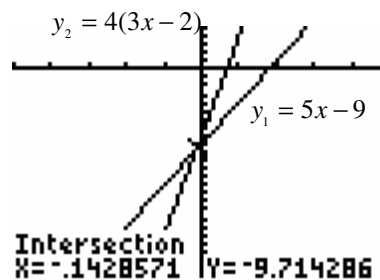
$$12x - 8 \leq 5x - 9$$

$$7x \leq -1$$

$$\frac{7x}{7} \leq \frac{-1}{7}$$

$$x \leq -\frac{1}{7}$$

Graphically:

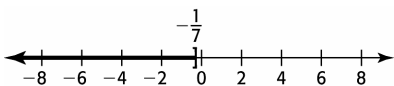


$[-5, 5]$  by  $[-25, 5]$

$4(3x - 2) \leq 5x - 9$  implies that the solution region is  $x \leq -\frac{1}{7}$ .

The interval notation is  $\left(-\infty, -\frac{1}{7}\right]$ .

The graph of the solution is:



4. Algebraically:

$$5(2x - 3) > 4x + 6$$

$$10x - 15 > 4x + 6$$

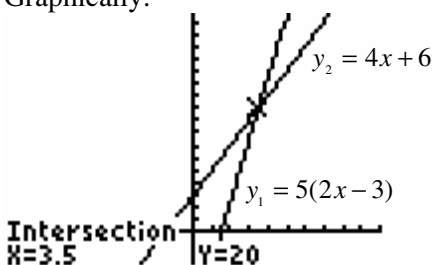
$$6x - 15 > 6$$

$$6x > 21$$

$$x > \frac{21}{6}$$

$$x > \frac{7}{2}$$

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:

$$4x + 1 < -\frac{3}{5}x + 5$$

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

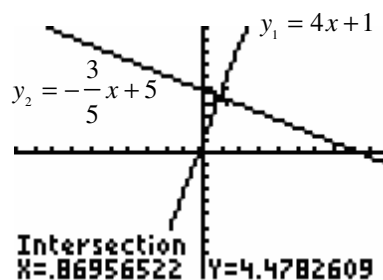
$$20x + 5 < -3x + 25$$

$$23x + 5 < 25$$

$$23x < 20$$

$$x < \frac{20}{23}$$

Graphically:

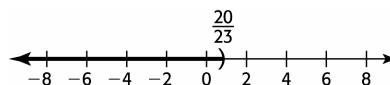


$[-10, 10]$  by  $[-10, 10]$

$4x + 1 < -\frac{3}{5}x + 5$  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:

$$4x - \frac{1}{2} \leq -2 + \frac{x}{3}$$

$$6\left(4x - \frac{1}{2}\right) \leq 6\left(-2 + \frac{x}{3}\right)$$

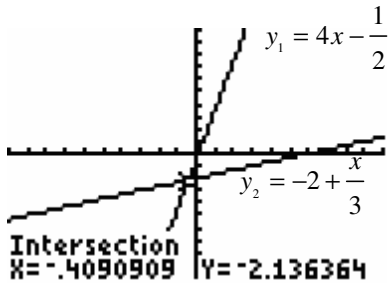
$$24x - 3 \leq -12 + 2x$$

$$22x - 3 \leq -12$$

$$22x \leq -9$$

$$x \leq -\frac{9}{22}$$

Graphically:

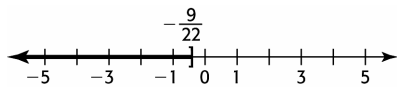


$[-10, 10]$  by  $[-10, 10]$

$4x - \frac{1}{2} \leq -2 + \frac{x}{3}$  implies that the solution region is  $x \leq -\frac{9}{22}$ .

The interval notation is  $\left(-\infty, -\frac{9}{22}\right]$ .

The graph of the solution is:



7. Algebraically:

$$\frac{x-5}{2} < \frac{18}{5}$$

$$10\left(\frac{x-5}{2}\right) < 10\left(\frac{18}{5}\right)$$

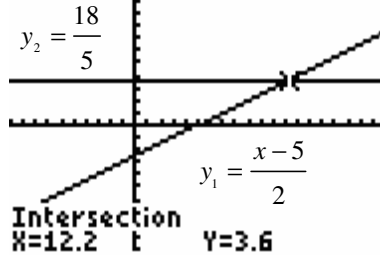
$$5(x-5) < 2(18)$$

$$5x - 25 < 36$$

$$5x < 61$$

$$x < \frac{61}{5}$$

Graphically:

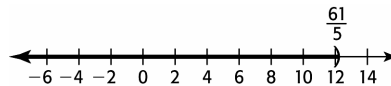


$[-10, 20]$  by  $[-10, 10]$

$\frac{x-5}{2} < \frac{18}{5}$  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

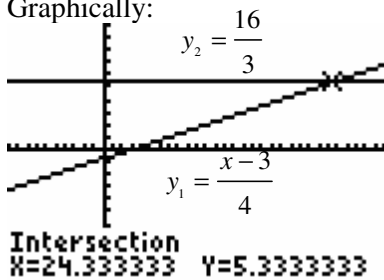




8. Algebraically:

$$\begin{aligned} \frac{x-3}{4} &< \frac{16}{3} \\ 12\left(\frac{x-3}{4}\right) &< 12\left(\frac{16}{3}\right) \\ 3(x-3) &< 64 \\ 3x-9 &< 64 \\ 3x &< 73 \\ x &< \frac{73}{3} \end{aligned}$$

Graphically:



$[-10, 30]$  by  $[-10, 10]$

$\frac{x-3}{4} < \frac{16}{3}$  implies that the solution region is  $x < \frac{73}{3}$ .

The interval notation is  $\left(-\infty, \frac{73}{3}\right)$ .

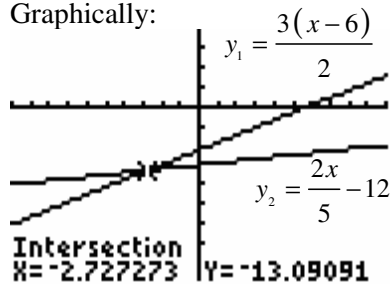
The graph of the solution is:



9. Algebraically:

$$\begin{aligned} \frac{3(x-6)}{2} &\geq \frac{2x}{5} - 12 \\ 10\left(\frac{3(x-6)}{2}\right) &\geq 10\left(\frac{2x}{5} - 12\right) \\ 5(3(x-6)) &\geq 2(2x) - 120 \\ 15(x-6) &\geq 4x - 120 \\ 15x - 90 &\geq 4x - 120 \\ 11x - 90 &\geq -120 \\ 11x &\geq -30 \\ x &\geq -\frac{30}{11} \end{aligned}$$

Graphically:

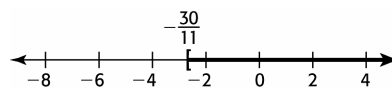


$[-10, 10]$  by  $[-35, 15]$

$\frac{3(x-6)}{2} \geq \frac{2x}{5} - 12$  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:

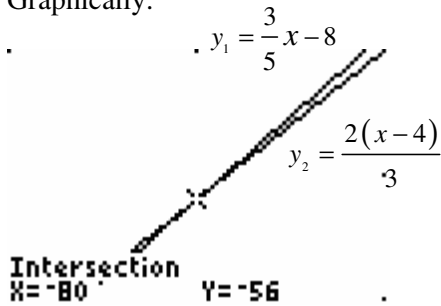
$$\frac{2(x-4)}{3} \geq \frac{3x}{5} - 8$$

$$15 \left[ \frac{2(x-4)}{3} \right] \geq 15 \left[ \frac{3x}{5} - 8 \right]$$

$$10x - 40 \geq 9x - 120$$

$$x \geq -80$$

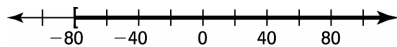
Graphically:



$[-90, -70]$  by  $[-60, -50]$

$\frac{2(x-4)}{3} \geq \frac{3x}{5} - 8$  implies that the solution region is  $x \geq -80$ .  
The interval notation is  $[-80, \infty)$ .

The graph of the solution is:



11. Algebraically:

$$2.2x - 2.6 \geq 6 - 0.8x$$

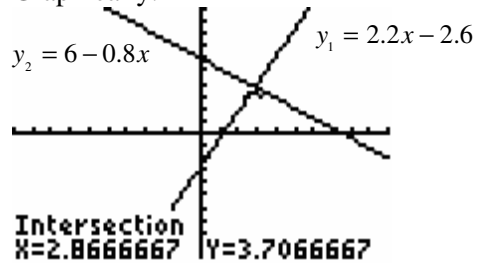
$$3.0x - 2.6 \geq 6$$

$$3.0x \geq 8.6$$

$$x \geq \frac{8.6}{3.0}$$

$$x \geq 2.8\bar{6}$$

Graphically:

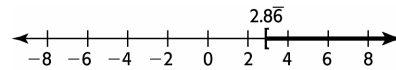


$[-10, 10]$  by  $[-10, 10]$

$2.2x - 2.6 \geq 6 - 0.8x$  implies that the solution region is  $x \geq 2.8\bar{6}$ .

The interval notation is  $[2.8\bar{6}, \infty)$ .

The graph of the solution is:



12. Algebraically:

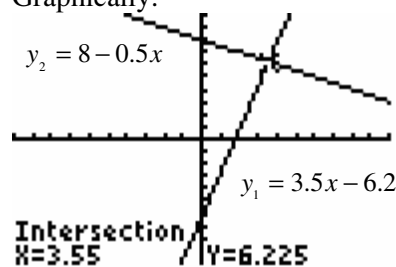
$$3.5x - 6.2 \leq 8 - 0.5x$$

$$4x \leq 14.2$$

$$x \leq \frac{14.2}{4}$$

$$x \leq 3.55$$

Graphically:

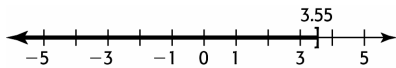


$[-10, 10]$  by  $[-10, 10]$

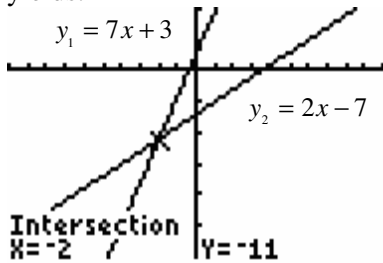
$3.5x - 6.2 \leq 8 - 0.5x$  implies that the solution region is  $x \leq 3.55$ .

The interval notation is  $(-\infty, 3.55]$ .

The graph of the solution is:



13. Applying the intersection of graphs method yields:

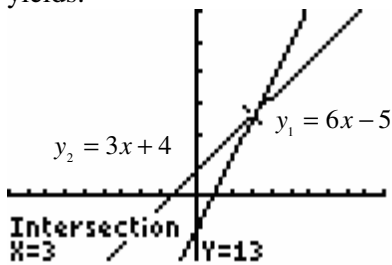


$[-10, 10]$  by  $[-30, 10]$

$7x + 3 < 2x - 7$  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  $[-10, 30]$

$3x + 4 \leq 6x - 5$  implies that the solution region is  $x \geq 3$ .

The interval notation is  $[3, \infty)$ .

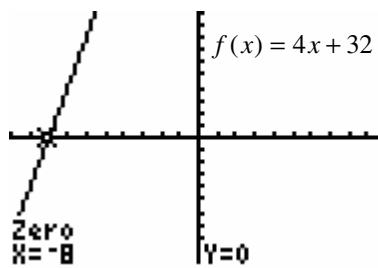
15. To apply the  $x$ -intercept method, first rewrite the inequality so that zero is on one side of the inequality.

$$5(2x + 4) \geq 6(x - 2)$$

$$10x + 20 \geq 6x - 12$$

$$4x + 32 \geq 0$$

Let  $f(x) = 4x + 32$ , and determine graphically where  $f(x) \geq 0$ .



$[-10, 10]$  by  $[-10, 10]$

$f(x) \geq 0$  implies that the solution region is  $x \geq -8$ .

The interval notation is  $[-8, \infty)$ .

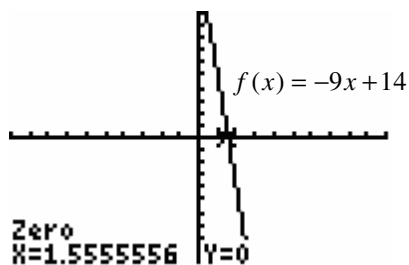
16. To apply the  $x$ -intercept method, first rewrite the inequality so that zero is on one side of the inequality.

$$-3(x - 4) < 2(3x - 1)$$

$$-3x + 12 < 6x - 2$$

$$-9x + 14 < 0$$

Let  $f(x) = -9x + 14$ , and determine graphically where  $f(x) < 0$ .



$[-10, 10]$  by  $[-10, 10]$

$f(x) < 0$  implies that the solution region is  $x > 1.5$ .

The interval notation is  $\left(\frac{14}{9}, \infty\right)$ .

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.  $17 \leq 3x - 5 < 31$

$$17 + 5 \leq 3x - 5 + 5 < 31 + 5$$

$$22 \leq 3x < 36$$

$$\frac{22}{3} \leq \frac{3x}{3} < \frac{36}{3}$$

$$\frac{22}{3} \leq x < 12$$

The interval notation is  $\left[\frac{22}{3}, 12\right)$ .

20.  $120 < 20x - 40 \leq 160$

$$120 + 40 < 20x - 40 + 40 \leq 160 + 40$$

$$160 < 20x \leq 200$$

$$8 < x \leq 10$$

The interval notation is  $(8, 10]$ .

21.  $2x + 1 \geq 6$  and  $2x + 1 \leq 21$

$$6 \leq 2x + 1 \leq 21$$

$$5 \leq 2x \leq 20$$

$$\frac{5}{2} \leq x \leq 10$$

$$x \geq \frac{5}{2} \text{ and } x \leq 10$$

The interval notation is  $\left[\frac{5}{2}, 10\right]$ .

22.  $16x - 8 > 12$  and  $16x - 8 < 32$

$$12 < 16x - 8 < 32$$

$$20 < 16x < 40$$

$$\frac{20}{16} < \frac{16x}{16} < \frac{40}{16}$$

$$\frac{5}{4} < x < \frac{5}{2}$$

$$x > \frac{5}{4} \text{ and } x < \frac{5}{2}$$

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

$$2x - 5 > 6$$

$$2x > 11$$

$$x > \frac{11}{2}$$

$$x < -\frac{8}{3} \text{ and } x > \frac{11}{2}$$

Since “and” implies that these two inequalities must both be true at the same time, and there is no set of numbers where this occurs, there is no solution to this system of inequalities.

24.  $6x - 2 \leq -5$  or  $3x + 4 > 9$

Inequality 1

$$6x - 2 \leq -5$$

$$6x \leq -3$$

$$x \leq -\frac{1}{2}$$

Inequality 2

$$3x + 4 > 9$$

$$3x > 5$$

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

$$x \leq -\frac{1}{2} \text{ or } x > \frac{5}{3}$$

Since “or” implies that one or the other of these inequalities is true, the solution for this system, in interval notation, is

$$\left(-\infty, -\frac{1}{2}\right] \cup \left(\frac{5}{3}, \infty\right)$$

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

$$3\left(\frac{2}{3}x - 1\right) \geq 3(2x - 2)$$

$$2x - 3 \geq 6x - 6$$

$$-4x \geq -3$$

$$x \leq \frac{3}{4}$$

$$x \geq \frac{32}{11} \text{ or } x \leq \frac{3}{4}$$

Since “or” implies that one or the other of these inequalities is true, the solution for this

system, in interval notation, is

$$\left(-\infty, \frac{3}{4}\right] \cup \left[\frac{32}{11}, \infty\right)$$

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

$$5\left(\frac{2}{5}x - 5\right) > 5(6x)$$

$$2x - 25 > 30x$$

$$-28x > 25$$

$$x < -\frac{25}{28}$$

$$x > -\frac{2}{3} \text{ or } x < -\frac{25}{28}$$

$$\left(-\infty, -\frac{25}{28}\right) \cup \left(-\frac{2}{3}, \infty\right)$$

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 2.4 Exercises

29. a.  $V = 12,000 - 2000t$

b.  $12,000 - 2000t < 8000$

c.  $12,000 - 2000t \geq 6000$

30. 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.

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.

The income from the second position will exceed the income from the first position when

$$2000 + 0.05x > 3100$$

$$0.05x > 1100$$

$$x > \frac{1100}{0.05}$$

$$x > 22,000$$

When monthly sales exceed \$22,000, the second position is more profitable than the first position.

34. Original value =  $(1000)(22) = \$22,000$

$$\begin{aligned} \text{Adjusted value} &= 22,000 - (22,000)(20\%) \\ &= 22,000 - 4400 \\ &= 17,600 \end{aligned}$$

Let  $x$  = percentage increase

$$17,600 + 17,600x > 22,000$$

$$17,600x > 4400$$

$$x > \frac{4400}{17,600}$$

$$x > 0.25$$

$$x > 25\%$$

The percent increase must be greater than 25% in order to ensure a profit.

35.

Let  $x$  = Stan's final exam grade.

$$80 \leq \frac{78 + 69 + 92 + 81 + 2x}{6} \leq 89$$

$$6(80) \leq 6\left(\frac{78 + 69 + 92 + 81 + 2x}{6}\right) \leq 6(89)$$

$$480 \leq 320 + 2x \leq 534$$

$$480 - 320 \leq 320 - 320 + 2x \leq 534 - 320$$

$$160 \leq 2x \leq 214$$

$$\frac{160}{2} \leq \frac{2x}{2} \leq \frac{214}{2}$$

$$80 \leq x \leq 107$$

If the final exam does not contain any bonus points, Stan needs to score between 80 and 100 to earn a grade of B for the course.

36. Let  $x$  = John's final exam grade.

$$70 \leq \frac{78 + 62 + 82 + 2x}{5} \leq 79$$

$$5(70) \leq 5\left(\frac{78 + 62 + 82 + 2x}{5}\right) \leq 5(79)$$

$$350 \leq 222 + 2x \leq 395$$

$$128 \leq 2x \leq 173$$

$$\frac{128}{2} \leq \frac{2x}{2} \leq \frac{173}{2}$$

$$64 \leq x \leq 86.5$$

John needs to score between 64 and 86.5 to earn a grade of C for the course.

37. a.  $2.1x + y = 82.1$

Solve for  $x$ :

$$2.1x = 82.1 - y$$

$$x = \frac{82.1 - y}{2.1}$$

b. Solve for  $y$  between the years

2000 ( $x = 10$ ) and 2009 ( $x = 19$ ):

$$10 \leq \frac{82.1 - y}{2.1} \leq 19$$

$$21 \leq 82.1 - y \leq 39.9$$

$$-61.1 \leq -y \leq -42.2$$

$$61.1 \geq y \geq 42.2, \text{ or}$$

$$42.2 \leq y \leq 61.1$$

Thus the range of cigarette use for the years 2000 to 2009 is 42.2% to 61.1%.

38. a.  $y \geq 1000$

$$0.97x + 128.3829 \geq 1000$$

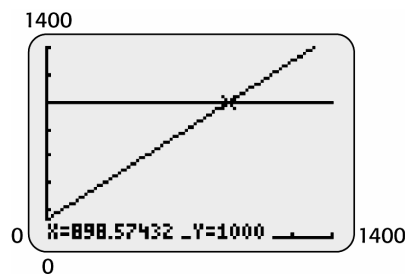
$$0.97x \geq 871.6171$$

$$x \geq \frac{871.6171}{0.97}$$

$$x \geq 898.57 \text{ or approximately } x \geq 899$$

Old scores greater than or equal to 899 are equivalent to new scores.

b.



39. a.

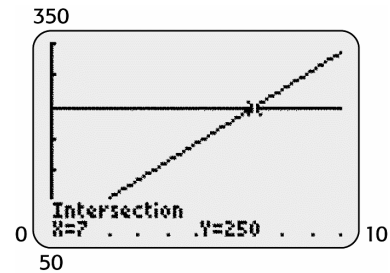


$$\begin{aligned}
 y &= 250 \\
 28.5x + 50.5 &= 250 \\
 28.5x &= 199.5 \\
 x &= \frac{199.5}{28.5} \\
 x &= 7
 \end{aligned}$$

Thus, the number of doctorates employed was 250 seven years after the year 2000, in the year 2007.

- c. Prior to 2007, the number of doctorates employed was below 250.

b.



40. If  $x$  is the number of years from 1995, and if  $y = 5.8x + 7.13$ , then the percent of households in the U.S. with Internet access greater than 88 is given by:

$$\begin{aligned}
 5.8x + 7.13 &\geq 88 \\
 5.8x &\geq 80.87 \\
 x &\geq 13.94 \approx 14 \text{ years after 1995}
 \end{aligned}$$

Therefore, 14 years from 1995 is 2009 and after.

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.

$$\begin{aligned}
 4(12) &< y < 6(12) \\
 48 &< 0.554x - 2.886 < 72 \\
 48 + 2.886 &< 0.554x - 2.886 + 2.886 < 72 + 2.886 \\
 50.886 &< 0.554x < 74.886 \\
 \frac{50.886}{0.554} &< \frac{0.554x}{0.554} < \frac{74.886}{0.554} \\
 91.85198556 &< x < 135.1732852 \\
 \text{or approximately, } 92 &< x < 135
 \end{aligned}$$

Thus, the prison sentence should be between 92 months and 135 months.

43. Let  $y > 9$ .

$$-0.146x + 11.074 > 9$$

$$-0.146x > 9 - 11.074$$

$$-0.146x > -2.074$$

$$x < \frac{-2.074}{-0.146} = 14.2$$

Thus when  $x < 14$  years after 1980, before 1994, the marriage rate per 1000 is greater than 9.

Let  $y < 8$ .

$$-0.146x + 11.074 < 8$$

$$-0.146x < 8 - 11.074$$

$$-0.146x < -3.074$$

$$x > \frac{-3.074}{-0.146} = 21.1$$

Thus when  $x > 21$  years after 1980, after 2001, the marriage rate per 1000 is less than 8.

44. Note that  $W$  and  $B$  are in thousands.

$$B \geq 100$$

$$1.05W - 18.691 \geq 100$$

$$1.05W \geq 118.691$$

$$W \geq \frac{118.691}{1.05}$$

$$W \geq 113.039$$

The median salary for whites would be at least \$113,039.

45. a. Since the rate of increase is constant, the equation modeling the value of the home is linear.

$$\begin{aligned} m &= \frac{y_2 - y_1}{x_2 - x_1} \\ &= \frac{270,000 - 190,000}{4 - 0} \\ &= \frac{80,000}{4} \\ &= 20,000 \end{aligned}$$

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.

$$y > 400,000$$

$$20,000x + 190,000 > 400,000$$

$$20,000x > 210,000$$

$$x > \frac{210,000}{20,000}$$

$$x > 10.5$$

2010 corresponds to

$$x = 2010 - 1996 = 14.$$

Therefore,  $11 \leq x \leq 14$ .

Or,  $y > 400,000$

between 2007 and 2010, inclusive.

The value of the home will be greater than \$400,000 between 2007 and 2010.

- c. Since the housing market took such a down turn in the last year or so, it does not seem reasonable that this model remained accurate until the end of 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<sup>th</sup> 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<sup>th</sup> car needs to be at least

$$32,500 + 3737.50 = 36,237.50 \text{ or } \$36,238.$$

**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.**  $P(x) > 84,355$

$$-40,255 + 9.80x > 84,355$$

$$9.80x > 124,610$$

$$x > \frac{124,610}{9.80}$$

$$x > 12,715.30612$$

Rounding since the data is discrete:

$$x > 12,715$$

The number of units produced and sold should 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

$$P(x) < 0$$

$$-40,255 + 9.80x < 0$$

$$9.80x < 40,255$$

$$x < \frac{40,255}{9.80}$$

$$x < 4107.653061$$

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.**  $T \leq 85$

$$0.43m + 76.8 \leq 85$$

$$0.43m \leq 8.2$$

$$m \leq \frac{8.2}{0.43}$$

$$m \leq 19.06976744 \text{ or approximately,}$$

$$m \leq 19$$

The temperature will be at most 85°F for the first 19 minutes.

53. Since at least implies greater than

or equal to,  $H(x) \geq 14.6$ . Thus,

$$0.224x + 9.0 \geq 14.6$$

$$0.224x \geq 5.6$$

$$x \geq \frac{5.6}{0.224}$$

$$x \geq 25$$

Thus, the Hispanic population is at least 14.6%, 25 years after 1990, on or after the year 2015.

54. a.

$$245 < y < 248$$

$$245 < 0.155x + 244.37 < 248$$

$$245 - 244.37 < 0.155x + 244.37 - 244.37 < 248 - 244.37$$

$$0.63 < 0.155x < 3.63$$

$$\frac{0.63}{0.155} < \frac{0.155}{0.155}x < \frac{3.63}{0.155}$$

$$4.06 < x < 23.42$$

Considering  $x$  as a discrete variable yields  $4 < x < 23$ .

From 1974 (1970 + 4) until 1993 (1970 + 23), the reading scores were between 245 and 248.

55. a.  $x = 2008 - 1990 = 18$

$$p(18) = 82.074 - 2.088(18)$$

$$= 82.074 - 37.584$$

$$= 44.49 \approx 44.5\%$$

In 2008, the percent of high school seniors who used cigarettes is estimated to be 44.5%.

56. a. Since "at least" implies greater than

or equal to,  $B(x) \geq 13.44$ . Thus,

$$0.057x + 12.3 \geq 13.44$$

$$0.057x \geq 1.14$$

$$x \geq \frac{1.14}{0.057}$$

$$x \geq 20$$

Thus, the percent of blacks is at least 13.44%, 20 years after 1990, on or after the year 2010.

b.

$x$	$Y_1$
9	63.282
10	61.194
11	59.106
12	57.018
13	54.93
14	52.842
15	50.754

$$x=12$$

$$p \geq 57.018 \text{ when } x \leq 12$$

c. Considering part b) above, the model

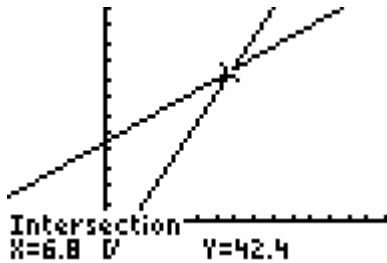
suggests that the percent is at least

57.018% before the year 2002.

## Chapter 2 Skills Check

1. a.

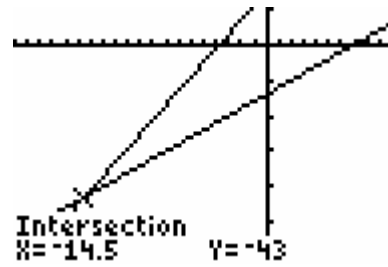
$$\begin{aligned}
 3x + 22 &= 8x - 12 \\
 3x - 8x + 22 &= 8x - 8x - 12 \\
 -5x + 22 &= -12 \\
 -5x + 22 - 22 &= -12 - 22 \\
 -5x &= -34 \\
 \frac{-5x}{-5} &= \frac{-34}{-5} \\
 x &= \frac{34}{5} = 6.8
 \end{aligned}$$

b. Applying the intersection of graphs method yields  $x = 6.8$ .

[-5, 15] by [-10, 60]

2. a.

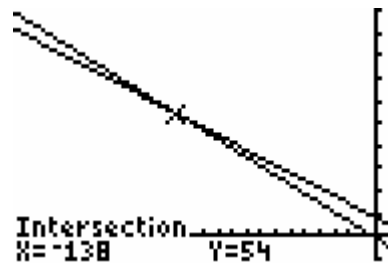
$$\begin{aligned}
 2(x - 7) &= 5(x + 3) - x \\
 2x - 14 &= 5x + 15 - x \\
 2x - 14 &= 4x + 15 \\
 2x - 4x - 14 &= 4x - 4x + 15 \\
 -2x - 14 &= 15 \\
 -2x - 14 + 14 &= 15 + 14 \\
 -2x &= 29 \\
 \frac{-2x}{-2} &= \frac{29}{-2} \\
 x &= -\frac{29}{2} = -14.5
 \end{aligned}$$

b. Applying the intersection of graphs method yields  $x = -14.5$ .

[-20, 10] by [-50, 10]

3. a.

$$\begin{aligned}
 \frac{3(x-2)}{5} - x &= 8 - \frac{x}{3} \\
 \text{LCD: } 15 & \\
 15\left(\frac{3(x-2)}{5} - x\right) &= 15\left(8 - \frac{x}{3}\right) \\
 3(3(x-2)) - 15x &= 120 - 5x \\
 3(3x - 6) - 15x &= 120 - 5x \\
 9x - 18 - 15x &= 120 - 5x \\
 -6x - 18 &= 120 - 5x \\
 -1x - 18 &= 120 \\
 -1x &= 138 \\
 x &= -138
 \end{aligned}$$

b. Applying the intersection of graphs method yields  $x = -138$ .

[-250, 10] by [-10, 100]

4. a.

$$\frac{6x+5}{2} = \frac{5(2-x)}{3}$$

$$\frac{6x+5}{2} = \frac{10-5x}{3}$$

LCD: 6

$$6\left(\frac{6x+5}{2}\right) = 6\left(\frac{10-5x}{3}\right)$$

$$3(6x+5) = 2(10-5x)$$

$$18x+15 = 20-10x$$

$$18x+15+10x = 20-10x+10x$$

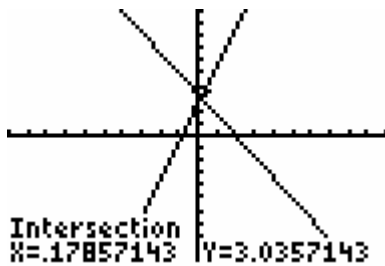
$$28x+15 = 20$$

$$28x+15-15 = 20-15$$

$$28x = 5$$

$$x = \frac{5}{28} \approx 0.179$$

b. Applying the intersection of graphs method yields  $x = 5 / 28 \approx 0.179$ .



$[-10,10]$  by  $[-10,-10]$

5. a.

$$\frac{3x}{4} - \frac{1}{3} = 1 - \frac{2}{3}\left(x - \frac{1}{6}\right)$$

$$\frac{3x}{4} - \frac{1}{3} = 1 - \frac{2}{3}x + \frac{1}{9}$$

LCD: 36

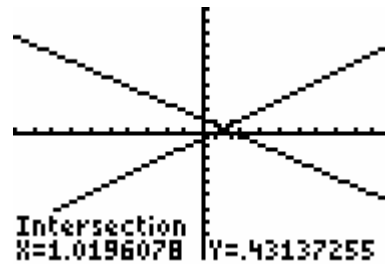
$$36\left(\frac{3x}{4} - \frac{1}{3}\right) = 36\left(1 - \frac{2}{3}x + \frac{1}{9}\right)$$

$$27x - 12 = 36 - 24x + 4$$

$$51x = 52$$

$$x = \frac{52}{51} \approx 1.0196$$

b. Applying the intersection of graphs method yields  $x = 52 / 51 \approx 1.0196$ .



$[-10,10]$  by  $[-10,-10]$

6. a.

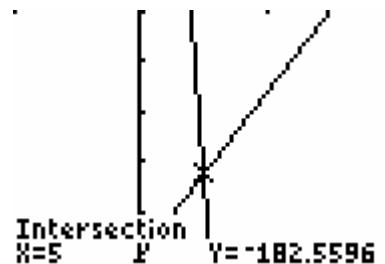
$$3.259x - 198.8546 = -3.8(8.625x + 4.917)$$

$$3.259x - 198.8546 = -32.775x - 18.6846$$

$$36.034x = 180.17$$

$$x = 5$$

b. Applying the intersection of graphs method yields  $x = 5$ .



$[-10, 20]$  by  $[-200, -150]$

7. a.  $f(x) = 7x - 105$

$$7x - 105 = 0$$

$$7x = 105$$

$$x = 15$$

b. The  $x$ -intercepts of the graph are the same as the zeros of the function.

c. Solving the equation  $f(x) = 0$  is the same as finding the zeros of the function and the  $x$ -intercepts of the graph.

8.

Solve for  $y$ :

$$P(a - y) = 1 + \frac{m}{3}$$

$$Pa - Py = 1 + \frac{m}{3}$$

$$-Py = 1 + \frac{m}{3} - Pa$$

$$-Py = \left( \frac{3 + m - 3Pa}{3} \right)$$

$$y = \left( \frac{3 + m - 3Pa}{-3P} \right)$$

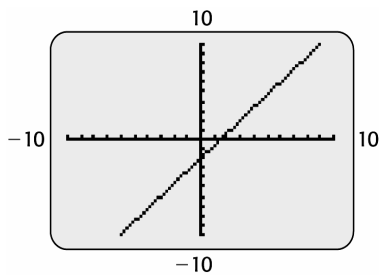
9. Solve for  $y$ :

$$4x - 3y = 6$$

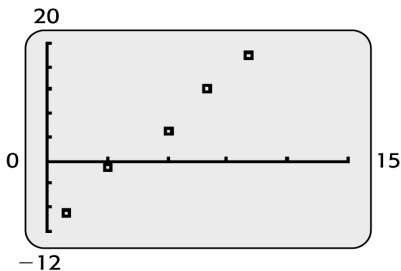
$$-3y = -4x + 6$$

$$y = \frac{-4x + 6}{-3} = \frac{4x - 6}{3}$$

$$y = \frac{4}{3}x - 2$$

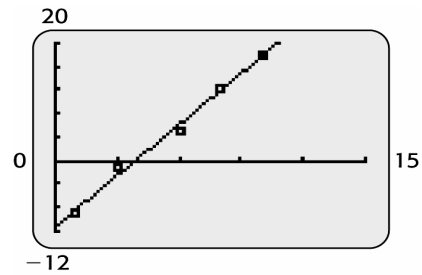


10.



11.  $y = 2.8947x - 11.211$

12.



13. No. The data points in the table do not fit the linear model exactly.

14.

$$\begin{cases} 3x + 2y = 0 & (Eq1) \end{cases}$$

$$\begin{cases} 2x - y = 7 & (Eq2) \end{cases}$$

$$\begin{cases} 3x + 2y = 0 & (Eq1) \end{cases}$$

$$\begin{cases} 4x - 2y = 14 & 2 \times (Eq2) \end{cases}$$

$$7x = 14$$

$$x = 2$$

Substituting to find  $y$

$$3(2) + 2y = 0$$

$$6 + 2y = 0$$

$$2y = -6$$

$$y = -3$$

The solution is  $(2, -3)$ .

$$\begin{aligned}
 15. \quad & \begin{cases} 3x + 2y = -3 & (Eq1) \\ 2x - 3y = 3 & (Eq2) \end{cases} \\
 & \begin{cases} 9x + 6y = -9 & 3 \times (Eq1) \\ 4x - 6y = 6 & 2 \times (Eq2) \end{cases} \\
 & 13x = -3 \\
 & x = -\frac{3}{13} \\
 & \text{Substituting to find } y \\
 & 3\left(-\frac{3}{13}\right) + 2y = -3 \\
 & -\frac{9}{13} + 2y = -\frac{39}{13} \\
 & 2y = -\frac{30}{13} \\
 & y = -\frac{15}{13} \\
 & \text{The solution is } \left(-\frac{3}{13}, -\frac{15}{13}\right).
 \end{aligned}$$

$$\begin{aligned}
 16. \quad & \begin{cases} -4x + 2y = -14 & (Eq1) \\ 2x - y = 7 & (Eq2) \end{cases} \\
 & \begin{cases} -4x + 2y = -14 & (Eq1) \\ 4x - 2y = 14 & 2 \times (Eq2) \end{cases} \\
 & 0 = 0 \\
 & \text{Dependent system. Infinitely many solutions.}
 \end{aligned}$$

$$\begin{aligned}
 17. \quad & \begin{cases} -6x + 4y = 10 & (Eq1) \\ 3x - 2y = 5 & (Eq2) \end{cases} \\
 & \begin{cases} -6x + 4y = 10 & (Eq1) \\ 6x - 4y = 10 & 2 \times (Eq2) \end{cases} \\
 & 0 = 20 \\
 & \text{No solution. Lines are parallel.}
 \end{aligned}$$

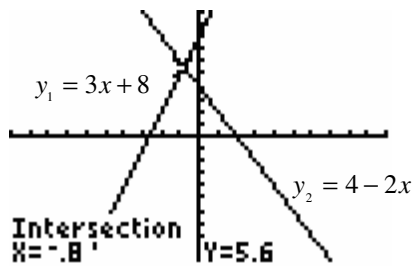
$$\begin{aligned}
 18. \quad & \begin{cases} 2x + 3y = 9 & (Eq1) \\ -x - y = -2 & (Eq2) \end{cases} \\
 & \begin{cases} 2x + 3y = 9 & (Eq1) \\ -2x - 2y = -4 & 2 \times (Eq2) \end{cases} \\
 & y = 5 \\
 & \text{Substituting to find } x \\
 & 2x + 3(5) = 9 \\
 & 2x + 15 = 9 \\
 & 2x = -6 \\
 & x = -3 \\
 & \text{The solution is } (-3, 5).
 \end{aligned}$$

$$\begin{aligned}
 19. \quad & \begin{cases} 2x + y = -3 & (Eq1) \\ 4x - 2y = 10 & (Eq2) \end{cases} \\
 & \begin{cases} 4x + 2y = -6 & 2 \times (Eq1) \\ 4x - 2y = 10 & (Eq2) \end{cases} \\
 & 8x = 4 \\
 & x = \frac{1}{2} \\
 & \text{Substituting to find } y \\
 & 2\left(\frac{1}{2}\right) + y = -3 \\
 & 1 + y = -3 \\
 & y = -4 \\
 & \text{The solution is } \left(\frac{1}{2}, -4\right).
 \end{aligned}$$

$$\begin{aligned}
 20. \quad & \text{Algebraically:} \\
 & 3x + 8 < 4 - 2x \\
 & 5x + 8 < 4 \\
 & 5x < -4 \\
 & x < -\frac{4}{5} = -0.8
 \end{aligned}$$



Graphically:



$[-10, 10]$  by  $[-10, 10]$

$3x + 8 < 4 - 2x$  implies that the solution is  $x < -\frac{4}{5}$ .

The interval notation is  $(-\infty, -\frac{4}{5})$ .

21. Algebraically:

$$3x - \frac{1}{2} \leq \frac{x}{5} + 2$$

$$10\left(3x - \frac{1}{2}\right) \leq 10\left(\frac{x}{5} + 2\right)$$

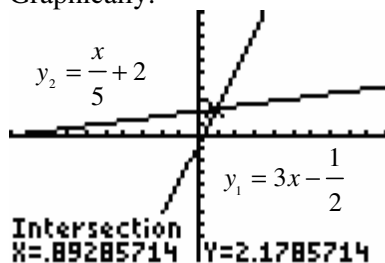
$$30x - 5 \leq 2x + 20$$

$$28x - 5 \leq 20$$

$$28x \leq 25$$

$$x \leq \frac{25}{28} \approx 0.893$$

Graphically:



$[-10, 10]$  by  $[-10, 10]$

$3x - \frac{1}{2} \leq \frac{x}{5} + 2$  implies that the

solution is  $x \leq \frac{25}{28}$ .

The interval notation is  $(-\infty, \frac{25}{28}]$ .

22. Algebraically:

$$18 \leq 2x + 6 < 42$$

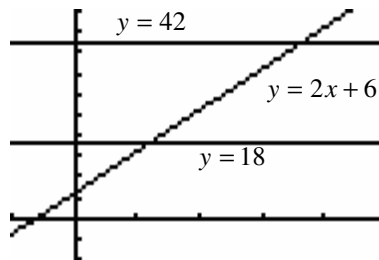
$$18 - 6 \leq 2x + 6 - 6 < 42 - 6$$

$$12 \leq 2x < 36$$

$$\frac{12}{2} \leq \frac{2x}{2} < \frac{36}{2}$$

$$6 \leq x < 18$$

Graphically:



$[-5, 25]$  by  $[-10, 50]$

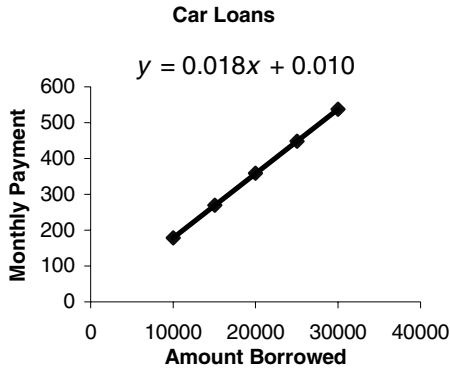
$18 \leq 2x + 6 < 42$  implies that the solution is  $6 \leq x < 18$ .

The interval notation is  $[6, 18)$ .

**Chapter 2 Review Exercises**

- 23. 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.

**c.**



Rounded model:  
 $P = f(A) = 0.018A + 0.010$

Unrounded model:  
 $f(A) = 0.017924A + 0.010$

- 24. a.** Using the linear model from part c) in problem 23:  
 $f(28,000) = 0.018(28,000) + 0.010$   
 $= 504.01$

The predicted monthly payment on a car loan of \$28,000 is \$504.01.

**b.** Yes. Any input could be used for A.

- c.**
- $$f(A) \leq 500$$
- $$0.017924A + 0.010 \leq 500$$
- $$0.017924A \leq 499.99$$
- $$A \leq \frac{499.99}{0.017924}$$
- $$A \leq 27,895.00$$

The loan amount should be less than or equal to \$27,895.00.

**25.**  $982.06t + 32,903.77 = 40,760.25$   
 $t = 8$ , and the year is 1998 (1990 + 8).

**26.**  $f(x) = 4500$

**27. a.** Let  $x$  = the number of years after 1990, and  $f(x)$  = the asparagus production in Switzerland. Then  $f(x) = 200$ .

**b.** This is a constant function.

**28. 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 second position will yield a greater salary.

29.

$$\text{Original Cost} = 24,000 \times 12 = 288,000$$

$$\text{Desired Profit} = 10\% (288,000) = 28,800$$

Revenue from 8 sold cars, with 12% avg profit

$$= 8(24,000 + 12\% \times 24,000)$$

$$= 8(24,000 + 2,880) = 215,040$$

Solve for  $x$  where  $x$  is the selling price of the remaining four cars.The total Revenue will be  $215,040 + 4x$ .

The desired 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.

30. 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 should invest \$300,000 in the safe account and \$120,000 in the risky account.

31. 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 1994 (1980 + 14).

32. Profit occurs when  $R(x) > C(x)$ .

$$500x > 48,000 + 100x$$

$$400x > 48,000$$

$$x > 120$$

The company will make a profit when producing and selling more than 120 units.

33. a.  $P(x) = 564x - (40,000 + 64x)$   
 $= 564x - 40,000 - 64x$   
 $= 500x - 40,000$

b.  $500x - 40,000 > 0$   
 $500x > 40,000$   
 $x > 80$

c. There is a profit when more than 80 units are produced and sold.

34. a.  $y + 15,000x = 300,000$   
 $y = 300,000 - 15,000x$   
 $300,000 - 15,000x < 150,000$   
 $-15,000x < -150,000$   
 $x > 10$

b. After 10 years, the property value will be below \$150,000.

35. a.  $m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{895 - 455}{250 - 150} = \frac{440}{100} = 4.4$

The average rate of change is \$4.40 per unit.

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

$$y - 455 = 4.4(x - 150)$$

$$y - 455 = 4.4x - 660$$

$$y = 4.4x - 205$$

$$P(x) = 4.4x - 205$$

b. Profit occurs when  $P(x) > 0$ .

$$4.4x - 205 > 0$$

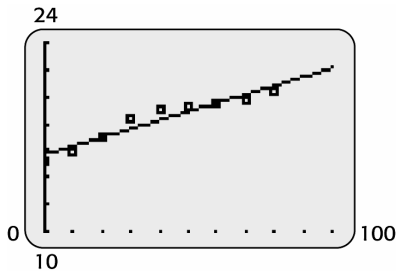
$$4.4x > 205$$

$$x = \frac{205}{4.4} = 46.5909 \approx 47$$

The company will make a profit when producing and selling at least 47 units.

36. a.  $y = 0.0638x + 15.702$

b.



c.  $f(99) = 0.0638(99) + 15.702$   
 $= 22.018$

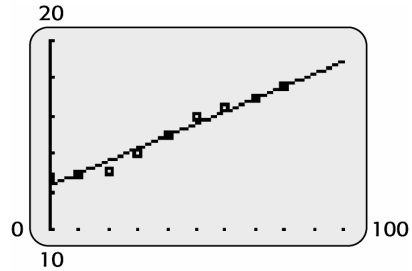
In 2049 (1950 + 99), the average woman is expected to live 22 years beyond age 65. Her life expectancy is 87 years.

d.  $y > 84 - 65 = 19$   
 $0.0638x + 15.702 > 19$   
 $0.0638x > 3.298$   
 $x > \frac{3.298}{0.0638}$

$x > 51.69$   
 In 2002 (1950 + 52) and beyond, the average woman is expected to live more than 84 years.

37. a.  $y = 0.0655x + 12.324$

b.



c.  $g(130) = 0.0655(130) + 12.324$   
 $= 8.515 + 12.324$   
 $= 20.839 \approx 20.8$

In 2080 (1050 + 130), a 65-year old male is expected to live 20.8 more years. The overall life expectancy is 86 years.

d.

A life expectancy of 90 years translates into  $90 - 65 = 25$  years beyond age 65.

Therefore, let  $g(x) = 25$ .

$$0.0655x + 12.324 = 25$$

$$0.0655x = 25 - 12.324$$

$$0.0655x = 12.676$$

$$x = \frac{12.676}{0.0655} = 193.527 \approx 194$$

In approximately the year 2144 (1950 + 194), male life expectancy will be 90 years.

- e. A life expectancy of 81 years translates into  $81 - 65 = 16$  years beyond age 65.

$$g(x) \leq 16$$

$$0.0655x + 12.324 \leq 16$$

$$0.0655x \leq 3.676$$

$$x \leq \frac{3.676}{0.0655}$$

$$x \leq 56.1$$

Since  $1950 + 56 = 2006$ , the average male could expect to live less than 81 years prior to 2007.

Using the unrounded model:

X	Y <sub>1</sub>
17	20901
18	21172
19	21444
20	21715.626
21	21987
22	22259
23	22530

Y<sub>1</sub> = 21715.626

The unrounded model predicts that population in 2020 will be approximately 21,715.626 thousand, or 21,716,000.

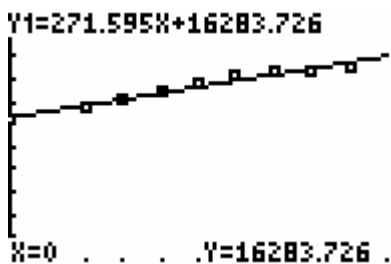
38. a.



[0, 10] by [10000, 21000]

Yes. A linear model would fit the data well. The data points lie approximately along a line.

b.

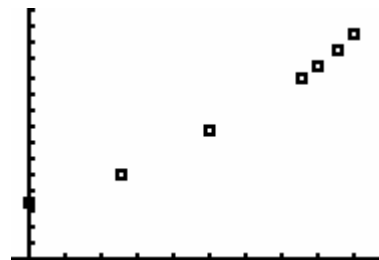


[0, 10] by [10000, 21000]

- c. In 2020,  $x = 2020 - 2000 = 20$ .  
 $y = 271.595(20) + 16,283.726$   
 $= 5431.9 + 16,283.726$   
 $= 21,715.626$

In 2020, the predicted population is 21,716,000.

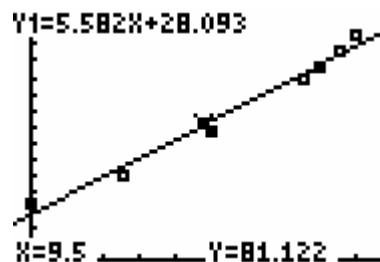
39. a.



[0, 20] by [0, 150]

Yes. A linear model would fit the data well. The data points lie approximately along a line.

b.



[0, 20] by [0, 150]

c. In 2012,  $x = 2012 - 1990 = 22$ .  
 $y = 5.582(22) + 28.093$   
 $= 122.804 + 28.093$   
 $= 150.897$

In 2012, the predicted personal expenditures for higher education is 150.9 billion dollars.

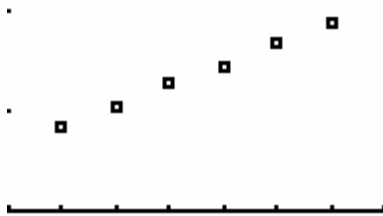
Using the unrounded model:

X	$Y_1$
19	134.15
20	139.73
21	145.32
22	150.9
23	156.48
24	162.06
25	167.64

$Y_1 = 150.897$

The unrounded model predicts that the personal expenditures for higher education in 2012 will be approximately \$150.9 billion, or \$150,900,000,000.

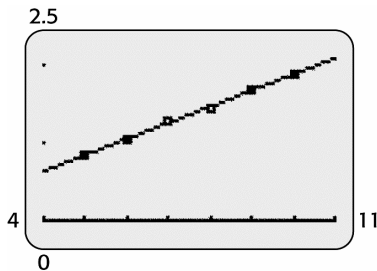
40. a.



[4, 11] by [0, 2.5]

b.  $y = 0.209x - 0.195$

c.



The line seems to fit the data points very well.

41.

$$y > 6$$

$$-0.146x + 11.074 > 6$$

$$-0.146x > -5.074$$

$$x < \frac{-5.074}{-0.146}$$

(Note the inequality sign switch.)

$$x < 34.753 \approx 35$$

$$y < 7$$

$$-0.146x + 11.074 < 7$$

$$-0.146x < -4.074$$

$$x > \frac{-4.074}{-0.146}$$

(Note the inequality sign switch.)

$$x > 27.9 \approx 28$$

The marriage rate will be between 6 and 7 during the years between 2008 (1980 + 28) and 2015 (1980 + 35).

42.

$$30p - 19x = 1$$

Then  $p = \frac{(1+19x)}{30}$

Since  $3.2 \leq p \leq 7.0$

$$3.2 \leq \frac{(1+19x)}{30} \leq 7.0$$

$$96 \leq 1+19x \leq 210$$

$$95 \leq 19x \leq 209$$

$$5 \leq x \leq 11$$

Thus, from 1995 through 2001, marijuana use was in the range of 3.2%–7.0%.

- 43.** Let  $3(12) \leq x \leq 5(12)$  or  
 $36 \leq x \leq 60$ . Years converted to months.  
 Then  
 $0.554(36) - 2.886 \leq y \leq 0.554(60) - 2.886$ .  
 Therefore,  $17.058 \leq y \leq 30.354$ . Or,  
 rounding to the months that include  
 this interval,  $17 \leq y \leq 31$ .

The criminal is expected to serve between  
 17 and 31 months inclusive.

- 44.** 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  $x$

$$x + 100,000 = 240,000$$

$$x = 140,000$$

They should invest \$140,000 in the safer  
 fund, and \$100,000 in the riskier fund.

- 45.** Let  $x$  = number of units.  
 $R = C$

$$565x = 6000 + 325x$$

$$240x = 6000$$

$$x = 25$$

25 units must be produced and sold to give a  
 break-even point.

- 46.** Let  $x$  = dosage of Medication A, and  
 let  $y$  = dosage of Medication B.

$$\begin{cases} 6x + 2y = 25.2 & (Eq1) \end{cases}$$

$$\begin{cases} \frac{x}{y} = \frac{2}{3} & (Eq2) \end{cases}$$

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.

- 47.** Let  $p$  = price and  $q$  = quantity.

$$\begin{cases} 3q + p = 340 & (Eq1) \end{cases}$$

$$\begin{cases} -4q + p = -220 & (Eq2) \end{cases}$$

$$\begin{cases} -3q - 1p = -340 & -1 \times (Eq1) \\ -4q + 1p = -220 & (Eq2) \end{cases}$$

$$\begin{cases} -3q - 1p = -340 & -1 \times (Eq1) \\ -4q + 1p = -220 & (Eq2) \end{cases}$$

$$-7q = -560$$

$$q = \frac{-560}{-7} = 80$$

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.

48. Let  $p$  = price and  $q$  = quantity.

$$\begin{cases} p = \frac{q}{10} + 8 & (Eq1) \\ 10p + q = 1500 & (Eq2) \end{cases}$$

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.

49. 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 must sell 1800 tickets at \$40 per ticket and 800 tickets at \$60 per ticket to yield \$120,000.

50. a.  $x + y = 500,000$

b.  $0.12x$

c.  $0.15y$

d.  $0.12x + 0.15y = 64,500$

e.

$$\begin{cases} x + y = 500,000 & (Eq1) \\ 0.12x + 0.15y = 64,500 & (Eq2) \end{cases}$$

$$\begin{cases} -0.12x - 0.12y = -60,000 & -0.12 \times (Eq1) \\ 0.12x + 0.15y = 64,500 & (Eq2) \end{cases}$$

$$\begin{cases} -0.12x - 0.12y = -60,000 & -0.12 \times (Eq1) \\ 0.12x + 0.15y = 64,500 & (Eq2) \end{cases}$$

$$0.03y = 4500$$

$$y = \frac{4500}{0.03} = 150,000$$

Substituting to calculate  $x$

$$x + 150,000 = 500,000$$

$$x = 350,000$$

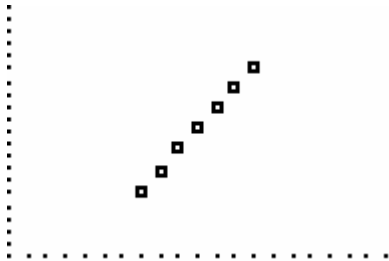
Invest \$350,000 in the 12% property and \$150,000 in the 15% property.



**Group Activity/Extended Application I: Taxes**

1. Domain is Taxable Income: {63,700; 63,800; 63,900; 64,000; 64,100; 64,200; 64,300}  
Range is Income Tax Due: {8779, 8804, 8829, 8854, 8879, 8904, 8929}

2.



[63000, 65000] by [8700, 9000]

10. Yes, the model can be used for any taxable income between \$63,700 and \$64,300, and therefore is a continuous function.

11. For  $x = 64150$

$$y = .25(64150) - 7146 = 8891.50.$$

Thus the tax due on \$64,150 is \$8891.50.

3. Yes, the points appear to lie on a line.
4. Yes, the inputs change by \$100, and the outputs change by \$25.
5. Yes, the rate of change is constant, and is \$.25 per \$1.00 of income.
6. Yes, a linear function will fit the data points exactly.
7. Using the first data point, (63700, 8779)  
 $y - 8779 = .25(x - 63700)$   
 $y - 8779 = .25x - 15925$   
 $y = .25x - 7146$
8. Using  $x = 63900$   
 $y = .25(63900) - 7146 = 8829,$   
 Using  $x = 64100$   
 $y = .25(64100) - 7146 = 8879$   
 Both results match the table values.
9. The table is a discrete function.