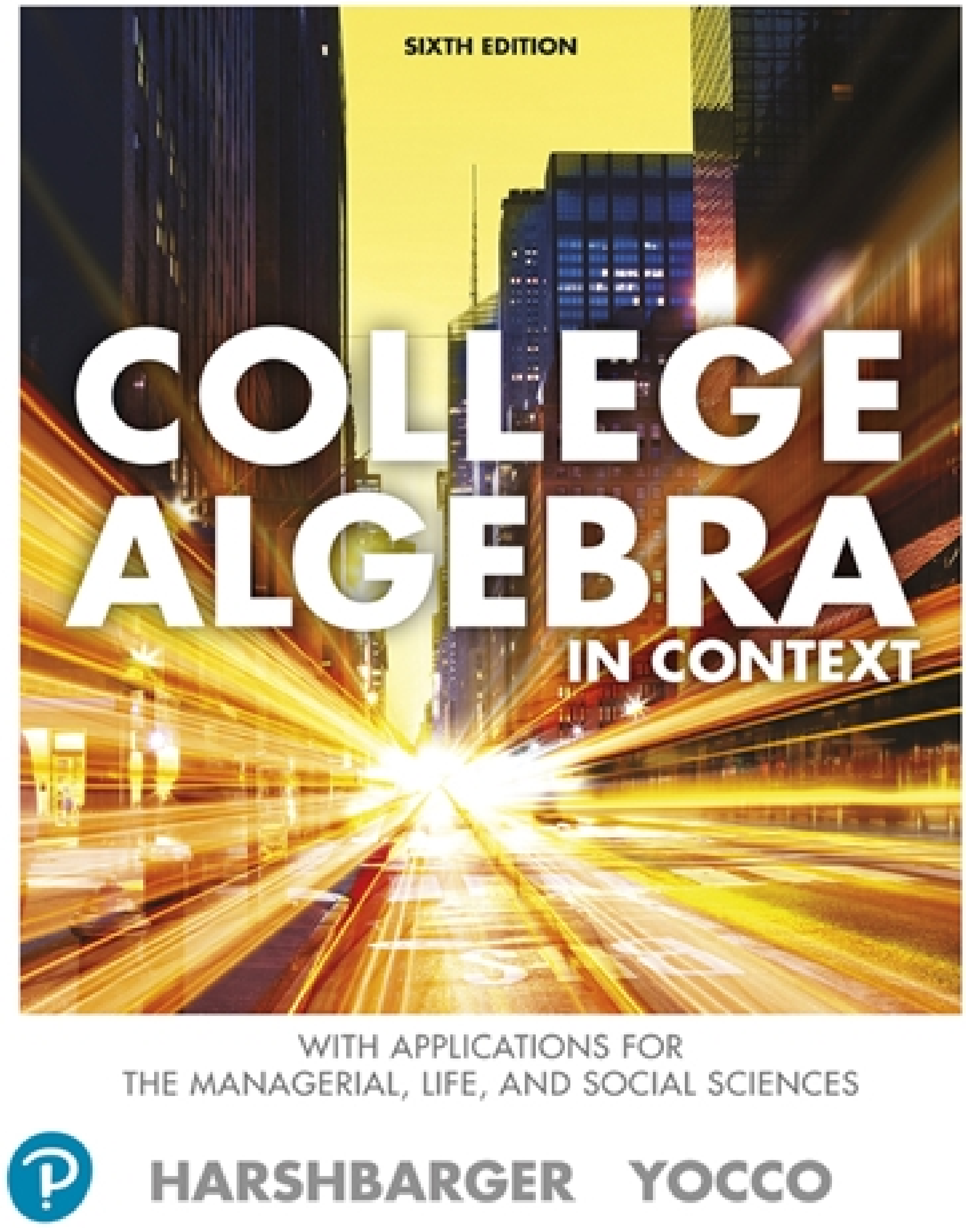
Solutions for College Algebra in Context with Applications for the Managerial Life and Social Sciences 6th Edition by Harshbarger



Solutions

INSTRUCTOR'S SOLUTIONS MANUAL

DEANA J. THORNOCK RICHMOND

COLLEGE ALGEBRA IN CONTEXT
WITH APPLICATIONS FOR THE MANAGERIAL, LIFE, AND SOCIAL SCIENCES

SIXTH EDITION

Ronald Harshbarger

University of South Carolina – Beaufort

Lisa S. Yocco

East Georgia State College

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Chapter 8 Special Topics in Algebra

CHAPTER 1
Functions, Graphs, and Models; Linear Functions

Toolbox Exercises

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

2. Yes

3. No. A is not a subset of B. A contains elements 2, 7, and 10, which are not in B.

4. No. $N = \{1,2,3,4,\ldots\}$, therefore $\frac{1}{2} \notin N$.

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

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

7. **a.** $A \cap B = \{-3, 0, \pi\}$

b. $A \cap B = \left\{-5,-3,-\frac{2}{3},0,\pi,4,5,7,\frac{15}{2},8\right\}$

8. Integers, rational numbers. The integers are a subset of the rational numbers. Exercise 5.

9. Rational numbers

10. Irrational numbers

11. $(-6)+(-16)=-22$

12. $22-(-13)=22+13=35$

13. $-56-(-34)=-56+34=-22$

14. $(-12)+(-6)-(-3)-6+(-14)$
$=-18+3-6-14$
$=-15-6-14$
$=-21-14$
$=-35$

15. $(-7)(-3)(2)=42$

16. $18 \div (-2)+(-16)(-3)=-9+48=39$

17. $\frac{35}{-7}+\frac{-42}{-6}=-5+7=2$

18. $[(-8)(-3)+5(-2)] \div [3(-4)-(-5)]$
$=[24-10] \div [-12+5]$
$=14 \div (-7)$
$=-2$

19. $(-3)(0)=0$

20. $\frac{0}{-6}=0$

21. $\frac{5}{0}$ is undefined.
Not possible; division by 0 is undefined.

22. **a.** $-8+6=6+(-8)$

b. $(-9)(3)=(3)(-9)$

23. **a.** $8+(-2)+3=8+(-2+3)$

b. $(-7)(3)(-4)=[(-7)(3)](-4)$

24. **a.** $6(12+5)=6(12)+6(5)=72+30$

b. $-(x+y)=-x-y$

25. This is an example of both the commutative and the associative property**.**

$(3+7)+8=(7+3)+8$ Commutative Property

$=7+(3+8)$ Associative Property

26. **a.** $-10+0=-10$

b. $1\cdot(3)=3$

27. **a.** $-4+4=0$

b. $7\cdot\frac{1}{7}=1$

28. $x>-3$

29. $-3\le x\le 3$

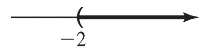
30. $x\le 3$

31. $(-\infty,7]$

32. $(3,7]$

33. $(-\infty,4)$

34.



35. $5>x\ge 2$ implies $2\le x<5$

36.

37. $-3x^2-4x+8$

The coefficient of $-3x^2$ is -3.

The coefficient of $-4x$ is -4.

The constant term is 8.

38. $5x^4+7x^3-3$

The coefficient of $5x^4$ is 5.

The coefficient of $7x^3$ is 7.

The constant term is -3.

39. $2a-4b=2(4)-4(-5)=8+20=28$

40. $-2y+\frac{3}{x}-5=-2(-7)+\frac{3}{6}-5$

$=14+\frac{1}{2}-5=\frac{19}{2}$

41. $3(2a-b)+0.6(b-3c)$

$=3(2(-2)-4)+0.6(4-3(0.8))$

$=3(-4-4)+0.6(4-2.4)$

$=3(-8)+0.6(1.6)$

$=-24+0.96$

$=-23.04$

42. $\frac{1}{2}bh=\frac{1}{2}(4.5)(6.5)=14.625$ sq ft

43. $16t^2 = 16(9)^2 = 16(81) = 1296$ feet

44. $(z^4 - 15z^2 + 20z - 6) + (2z^4 + 4z^3 - 12z^2 - 5)$
$= (z^4 + 2z^4) + 4z^3 + (-15z^2 - 12z^2)$
$+ 20z + (-6 - 5)$
$= 3z^4 + 4z^3 - 27z^2 + 20z - 11$

45. $3x + 2y^4 - 2x^3y^4 - 119 - 5x - 3y^2 + 5y^4 + 110$
$= (2y^4 + 5y^4) - 2x^3y^4 - 3y^2$
$+ (3x - 5x) + (-119 + 110)$
$= 7y^4 - 2x^3y^4 - 3y^2 - 2x - 9$

46. $4(p + d) = 4(p) + 4(d)$
$= 4p + 4d$

47. $-2(3x - 7y) = -2(3x) - 2(-7y)$
$= -6x + 14y$

48. $-a(b + 8c) = -a(b) - a(8c)$
$= -ab - 8ac$

49. $4(x - y) - (3x + 2y)$
$= 4x - 4y - 3x - 2y$
$= x - 6y$

50. $4(2x - y) + 4xy - 5(y - xy) - (2x - 4y)$
$= 8x - 4y + 4xy - 5y + 5xy - 2x + 4y$
$= (8x - 2x) + (4xy + 5xy) + (-4y - 5y + 4y)$
$= 6x + 9xy - 5y$

51. $2x(4yz - 4) - (5xyz - 3x)$
$= 8xyz - 8x - 5xyz + 3x$
$= (8xyz - 5xyz) + (-8x + 3x)$
$= 3xyz - 5x$

52. Subtraction property
$x + 7 = 11$
$x + 7 - 7 = 11 - 7$
$x = 4$

53. Addition property
$x - 4 = -10$
$x - 4 + 4 = -10 + 4$
$x = -6$

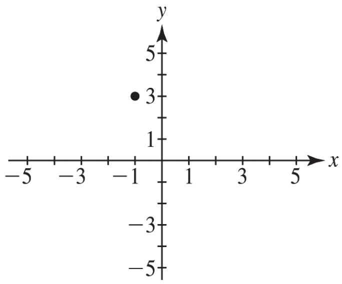
54. Division property
$5x = -20$
$\frac{5x}{5} = \frac{-20}{5}$
$x = -4$

55. Division property
$-2x = 18$
$\frac{-2x}{-2} = \frac{18}{-2}$
$x = -9$

56. Multiplication property
$\frac{y}{6} = 3$
$6\left(\frac{y}{6}\right) = 6(3)$
$y = 18$

57. Multiplication property
$\frac{-p}{4} = -8$
$-4\left(\frac{-p}{4}\right) = -4(-8)$
$p = 32$

58.



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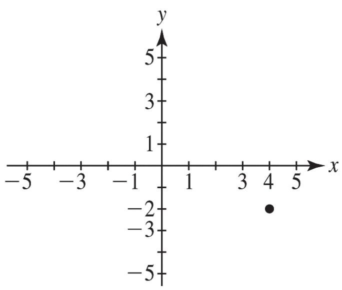

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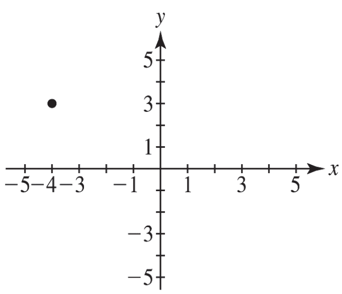

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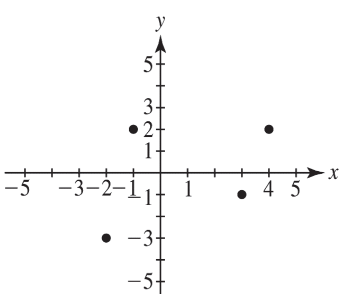

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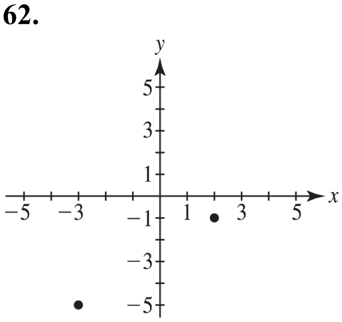


Skills Check 1.1

1. Use Table A.

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

b. $f(-5)$ is an output of the function.

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

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

2. Use Table B.

a. 0 is an x-value and therefore is an input of the function $g(x)$.

b. $g(7)$ is an output of the function.

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

d. Each input x of the function g yields exactly one output $y = g(x)$.

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

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

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

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

7. **a.** $f(2)=-1,$ since $x=2$ in the table corresponds with $f(x)=-1.$

b. $f(2)=10-3(2)^2$
$=10-3(4)$
$=10-12$
$=-2$

c. $f(2)=-3,$ since $(2,-3)$ is a point on the graph.

8. **a.** $f(-1)=5,$ since $(-1,5)$ is a point on the graph.

b. $f(-1)=-8,$ since $x=-1$ in the table corresponds with $f(x)=-8.$

c. $f(-1)=(-1)^2+3(-1)+8$
$=1-3+8$
$=6$

9.

x	y
0	2
–2	–4

10.

x	y
4	1
–4	–3

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

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

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

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

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

a. $C(3)=16-2(3)^2=16-2(9)=16-18=-2$

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

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

13. Yes. Each input corresponds with one output.
$D=\{-1,0,1,2,3\}$; $R=\{-8,-1,2,5,7\}$

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

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

16. Yes. The graph passes the vertical line test. Each input matches with exactly one output.

17. Yes. The graph passes the vertical line test. Each input matches with exactly one output..

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

19. No. If $x=3,$ then $y=5$ or $y=7.$
One value of x, 3, gives two values of y.

20. Yes. Each input x yields exactly one output y.

21. **a.** This is not a function.
If $x=4,$ then $y=12$ or $y=8.$

b. This is a function.
Each input yields exactly one output.

22. **a.** Yes. Each input yields exactly one output.

b. This is not a function.
If $x=3,$ then $y=4$ or $y=6.$

23. **a.** This is not a function.
If $x=2,$ then $y=3$ or $y=4.$

b. This is a function.
Each input yields exactly one output.

24. **a.** This is a function.
Each input yields exactly one output.

b. This is not a function.
If $x=-3,$ then $y=3$ or $y=-5.$

25. The domain is the set of all inputs.
$D=\{-3,-2,-1,1,3,4\}$
The range is the set of all outputs.
$R=\{-8,-4,2,4,6\}$

26. The domain is the set of all inputs.
$D=\{-6,-4,-2,0,2,4\}$
The range is the set of all outputs.
$R=\{-5,-2,0,1,4,6\}$

27. Consider y as a function of x.
Domain is the set of all inputs x. $D=[-10, 8]$
Range is the set of all outputs y. $R=[-12, 2]$

28. Consider y as a function of x.
Domain is the set of all inputs x. $D=[-4, 3]$
Range is the set of all outputs y. $R=[-1, 4]$

29. Consider y as a function of x.
Domain is the set of all inputs x. $D=(-\infty,\infty)$
Range is the set of all outputs y. $R=[-4,\infty)$

30. Consider y as a function of x.
Domain is the set of all inputs x. $D=(-\infty,3]$
Range is the set of all outputs y. $R=[0,\infty)$

31. The input is the number of years after 2000.
The year 2015 is 15 years after 2000; $x=15$.
The year 2022 is 22 years after 2000; $x=22$.

32. The input is the number of years after 1990.
The year 1990 is 0 years after 1990; $x=0$.
The year 2015 is 25 years after 1990; $x=25$.

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

34. Yes. Each input for x corresponds with exactly one output for y.

35. $F=\frac{9C}{5}+32,$ where F is the Fahrenheit temperature and C is the Celsius temperature.

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

37. Convert F temperature to C temperature using the following steps.
a. Subtract 32.
b. Multiply by 5.
c. Divide by 9.

38. Represent the function D using the following steps.
a. Square E.
b. Multiply by 3.
c. Subtract 5.

Exercises 1.1

39. No. There are two different outputs for $Y=20$.

40. Yes. Each input corresponds with exactly one output.

41. **a.** Yes. Each input (year) corresponds with exactly one output (revenue).
b. $D=\{2014,2015,2016,2017,2018,2019,$ $2020,2021,2022,2023,2024\}$
$R=\{207.3,240.3,290.1,349.3,414.0,454.2,$ $475.1,497.0,515.7,532.2,544.8\}$

42. T, temperature, is a function of m, the number of minutes after the power outage. Each value for m corresponds with exactly one value for T. The graph of the equation passes the vertical line test.

43. a. Yes. Each input (barcode) corresponds with exactly one output (price).

b. No. An input (price) could correspond with more than one output (barcode). Numerous items can have the same price but different barcodes.

44. a. Yes. Each input (piano key) corresponds with exactly one output (note). The domain is the set of all inputs and there are 12 keys on the piano, so there are 12 elements in the domain of the function.

b. Yes. Each input (note) corresponds with exactly one output (piano key). The range is the set of all outputs and there are 12 keys, so there are 12 elements in the range of the function.

45. Each input x (in years) corresponds with one output V, the value of the property.

46. Yes. Each input d (depth) corresponds with exactly one output p (pressure).

47. a. Yes. Each input (day) corresponds with exactly one output (weight).

b. The domain is the first 14 days of May. $D = \{1,2,3,4,5,6,7,8,9,10,11,12,13,14\}$

c. The range is the list of weights. $R = \{171,172,173,174,175,176,177,178\}$

d. Highest weights were on May 1 and 3.

e. Lowest weight was on May 14.

f. Longest period during which his weight decreased is 3 days, May 8 to 11.

48. a. No. This is not a function. One input of 75 corresponds with two outputs of 70 and 81.

b. Yes. This is a function. Each input (average score on final exam) corresponds with exactly one output (average score on math placement test).

49. a. $P(3) = 1096.78$

If the car is financed over 3 years, the payment is \$1096.78.

b. $C(5) = 42{,}580.80$

The total cost if financed over 5 years is \$42,580.80.

c. $C(4) = 41{,}014.08$

If the total cost is \$41,014.08, then the car has been financed over 4 years

d. $C(5) = 42{,}580.80;\ \ C(3) = 39{,}484.08$

The savings would be $\$42{,}580.80 - \$39{,}484.08 = \$3096.72$.

50. a. $f(103{,}000) = 20$

They must make payments for 20 years.

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

It will take the couple 30 years to pay off a \$120,000 mortgage at 7.5%.

c. $f(3 \cdot 40{,}000) = f(120{,}000) = 30$

d. If $A = 40{,}000$ then $f(A) = f(40{,}000) = 5$.

e. $f(3 \cdot 40{,}000) = f(120{,}000) = 30$

$3 \cdot f(40{,}000) = 3 \cdot 5 = 15$

The expressions are not equal.

51. a. Approximately 79.3 million

b. $f(2050) = 91.5$ Approximately 91.5 million women are projected to be in the workforce in 2050.

c. $D = \{1950, 1960, 1970, 1980, 1990, 2000, 2010, 2020, 2030, 2040, 2050\}$

d. As the year increases, the number of women in the workforce also increases.

52. a. In $t = 2020$, the ratio is about 3 to 1.

b. $f(2005) = 4$. In 2005, the projected ratio of the working-age population to the elderly population is 4 to 1.

c. $D = \{1995, 2000, 2005, 2010, 2015, 2020, 2025, 2030\}$

d. As the years increase, the projected ratio of the working-age population to the elderly population decreases.

53. a. $f(25{,}000) = \$14.15$

$f(75{,}000) = \$42.44$

b. $g(50{,}000) = \$12.83$

$g(100{,}000) = \$25.67$

c. If $f(x) = 28.29$, $x = 50{,}000$.

d. Yes

54. a. $f(2030) = 39{,}244$

b. In 2030, the population of females under the age of 18 is projected to be 39,244,000.

c. The function is increasing.

55. a. In 2020, 5.7 million U.S. citizens age 65 and older are expected to have Alzheimer's disease.

b. $f(2030) = 7.7.$ In 2030, 7.7 million U.S. citizens age 65 and older are expected to have Alzheimer's disease.

c. 2040; $f(2040) = 11$

d. Since 2000, the number of U.S citizens 65 and older that are expected to have Alzheimer's disease is increasing.

56. a. Yes. Each year, *t*, corresponds with exactly one number of jobs, *N*.

b. $f(2025) = 12.9$ (million)

c. In 2025, there will be 12.9 million jobs.

d. 2035; $f(2035) = 11.8$

57. a. $f(2030) = 15.8;$ 15.8%

b. $f(2040) = 17.1.$ The projected percent of the U.S. population that is foreign-born in 2040 is 17.1%.

c. $f(2050) = 18.2.$ This population is projected to be 18.2% in the year 2050.

d. $D = \{2020, 2030, 2040, 2050, 2060\}$

e. The projected population of the U.S. population that is foreign-born is increasing.

58. a. $f(1990) = 3.4$

In 1990, there were 3.4 workers for each retiree.

b. 2030; $f(2030) = 2$

c. As time passes, the number of workers decreases. Funding for Social Security in the future is problematic. Workers may need to pay a larger portion of salaries to fund benefits to retirees.

59. a. $R(200) = 32(200) = 6400$

The revenue from the sale of 200 hats is \$6400.

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

60. a. $C(200) = 4000 + 12(200) = 6400$

The cost of producing 200 hats is \$6400.

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

61. a.
$$\begin{aligned} f(1000) &= 0.857(1000) + 19.35 \\ &= 857 + 19.35 \\ &= 876.35 \end{aligned}$$

The charge for 1000 kilowatt hours is \$876.35.

b.
$$\begin{aligned} f(1500) &= 0.857(1500) + 19.35 \\ &= 1285.50 + 19.35 \\ &= 1304.85 \end{aligned}$$

The charge for 1500 kilowatt hours is \$1304.85.

62. a.
$$\begin{aligned} P(500) &= 450(500) - 0.1(500)^2 - 2000 \\ &= 225{,}000 - 25{,}000 - 2000 \\ &= 198{,}000 \end{aligned}$$

The profit from the production and sale of 500 iPod players is \$198,000.

b. $P(4000)$

$$\begin{aligned} &= 450(4000) - 0.1(4000)^2 - 2000 \\ &= 1{,}800{,}000 - 1{,}600{,}000 - 2000 \\ &= 198{,}000 \end{aligned}$$

The profit from the production and sale of 4000 iPod players is \$198,000.

63. a. $P(100) = 32(100) - 0.1(100)^2 - 1000$
$= 3200 - 1000 - 1000$
$= 1200$
Daily profit from producing and selling 100 Blue Chief bicycles is \$1200.

b. $P(160) = 32(160) - 0.1(160)^2 - 1000$
$= 5120 - 2560 - 1000$
$= 1560$
Daily profit from producing and selling 160 Blue Chief bicycles is \$1560.

64. a. $h(1) = 6 + 96(1) - 16(1)^2$
$= 6 + 96 - 16$
$= 86$
Height of ball after one second is 86 feet.

b. $h(3) = 6 + 96(3) - 16(3)^2$
$= 6 + 288 - 144$
$= 150$
Height of ball after 3 seconds is 150 feet.

c. Test $t = 2$: $h(2) = 6 + 96(2) - 16(2)^2$
$= 6 + 192 - 64$
$= 134$
Test $t = 4$. $h(4) = 6 + 96(4) - 16(4)^2$
$= 6 + 384 - 256$
$= 134$
Test $t = 5$. $h(5) = 6 + 96(5) - 16(5)^2$
$= 6 + 480 - 400$
$= 86$
It appears that the ball reaches a high point after 3 seconds and begins to fall. At 1 and 5 seconds, and again at 2 and 4 seconds, the respective heights are equal.

65. a. $0.3 + 0.7n = 0$
$0.7n = -0.3$
$\frac{0.7n}{0.7} = \frac{-0.3}{0.7}$
$n = -\frac{3}{7}$
The domain of $R(n)$ is all real numbers except $-\frac{3}{7}$ or $\left(-\infty, -\frac{3}{7}\right) \cup \left(-\frac{3}{7}, \infty\right)$.

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

66. a. Yes. Each value of s corresponds with exactly one value of K_c.

b. In order for the value of K_c to be real, the radicand, $4s + 1$, must be greater than or equal to zero.
$4s + 1 \geq 0$
$4s \geq -1$
$s \geq -\frac{1}{4}$
The domain is all real numbers greater than or equal to $-\frac{1}{4}$ or, $\left[-\frac{1}{4}, \infty\right)$.

c. s represents wind speed, and cannot be less than zero. The domain is restricted based on the context of the problem. The actual domain in context is $[0, \infty)$.

67. a. Since p is a percentage, $0 \leq p \leq 100$. In the given function, the denominator, $100 - p$, cannot equal zero, so $p \neq 100$. The domain is $0 \leq p < 100$ or $[0, 100)$.

b. $C(60) = \frac{237{,}000(60)}{100 - 60} = 355{,}500$
$C(90) = \frac{237{,}000(90)}{100 - 90} = 2{,}133{,}000$

68. a. Since the square root expression is in the denominator of the function, the radicand must be positive.
$2p + 1 > 0$
$2p > -1$
$p > -\frac{1}{2}$
The domain of q is $\left(-\frac{1}{2}, \infty\right)$.
In the context of the problem, p represents the price of a product and cannot be negative. $D = [0, \infty)$
In context, q represents the quantity of the product demanded by consumers. It cannot be 0 and can be no larger than 100. $R = (0, 100]$

69. a. $V(12) = (12)^2 (108 - 4(12))$
$= 144(108 - 48)$
$= 144(60)$
$= 8640$

$V(18) = (18)^2 (108 - 4(18))$
$= 324(108 - 72)$
$= 324(36)$
$= 11,664$

b. First, x represents a side length so $x > 0$. Second, to satisfy postal restrictions, the length (longest side) plus the girth must be less than or equal to 108 inches.

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

x is greatest if length is minimized, so let Length $= 0$ and find x.

$x \le 27 - \frac{0}{4}$ and $x \le 27$

The conditions on x are $0 < x \le 27$.
If $x = 27$, the length would be zero and the package would not exist. In context, $0 < x < 27$ and the corresponding domain for the function $V(x)$ is $(0, 27)$.

c.

x	*Volume*
10	6,800
15	10,800
20	11,200
21	10,584
19	11,552
18	**11,664**
17	11,560

The table shows a maximum volume of 11,664 cubic inches when $x = 18$.
length + girth = 108, so length + $4x$ =
length + $4(18) = 108$, and length = 36.
The dimensions that maximize the volume of the box are 18 inches by 18 inches by 36 inches.

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

b. $S(9) = -4.9(9)^2 + 98(9) + 2 = 487.1$
$S(0) = -4.9(10)^2 + 98(10) + 2 = 492$
$S(11) = -4.9(11)^2 + 98(11) + 2 = 487.1$

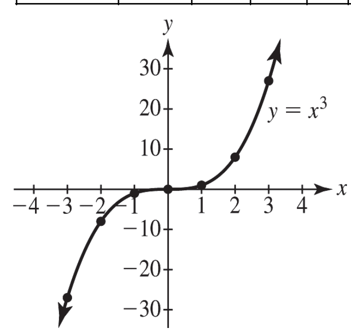
c. The bullet appears to reach a maximum height at 10 seconds, then begins to fall.

t	*Height*
9	487.1
9.5	490.78
10	492
10.5	490.78
11	487.1

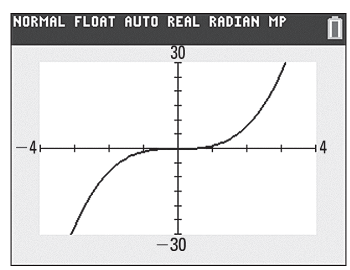
Skills Check 1.2

1. a.

x	−3	−2	−1	0	1	2	3
$y = x^3$	−27	−8	−1	0	1	2	3



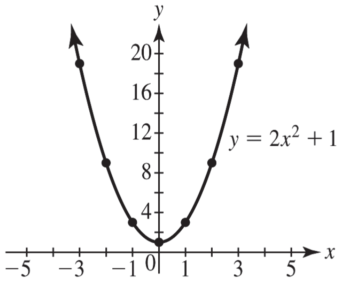
b.



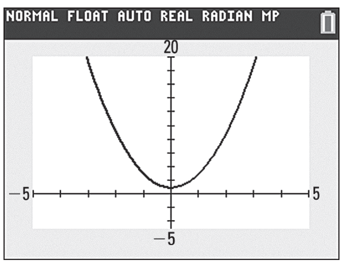
c. The graph in part (a) is generated by plotting points from the table and matches the calculator graph in part (b).

2. a.

x	−3	−2	−1	0	1	2	3
$y=2x^2+1$	19	9	3	1	3	9	19



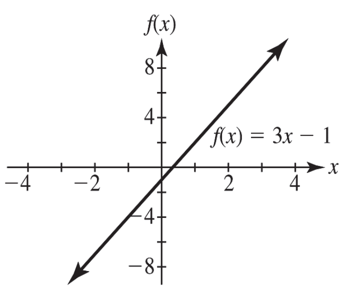
b.



c. The graph in part (a) is generated by plotting points from the table and matches the calculator graph in part (b).

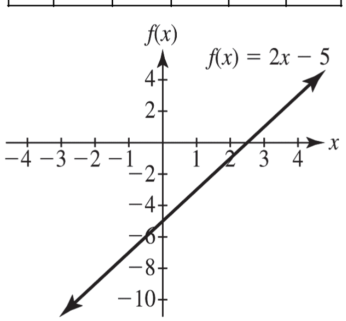
3.

x	−2	−1	0	1	2
$f(x)$	−7	−4	−1	2	5



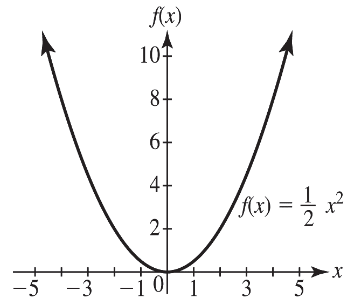
4.

x	−2	−1	0	1	2
y	−9	−7	−5	−3	−1



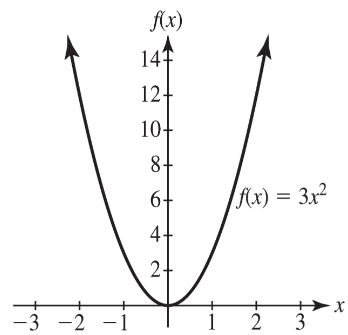
5.

x	−4	−2	0	2	4
$f(x)$	8	2	0	2	8



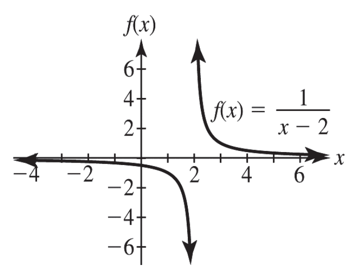
6.

x	−2	−1	0	1	2
y	12	3	0	3	12



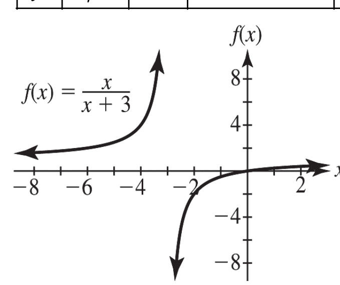
7.

x	−2	−1	0	1	2	3	4
$f(x)$	−1/4	−1/3	−1/2	−1	undef	1	1/2



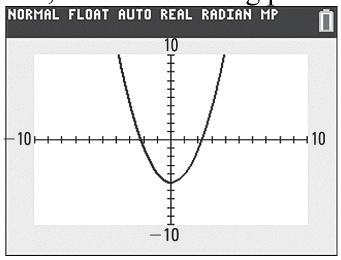
8.

x	−5	−4	−3	−2	−1
y	5/2	4	undefined	−2	−1/2



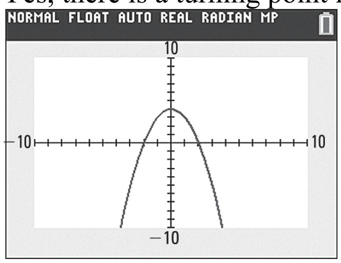
9. $y = x^2 - 5$

Yes, there is a turning point in this window.



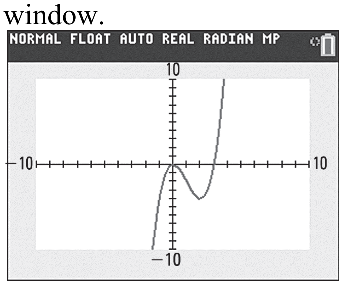
10. $y = 4 - x^2$

Yes, there is a turning point in this window



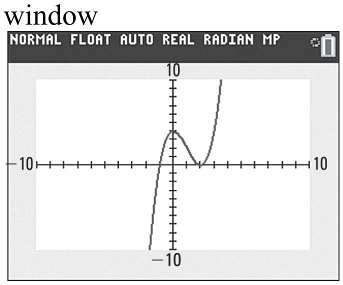
11. $y = x^3 - 3x^2$

Yes, there are two turning points in this window.



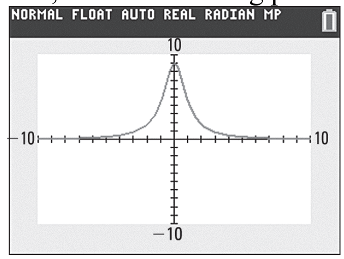
12. $y = x^3 - 3x^2 + 4$

Yes, there are two turning points in this window



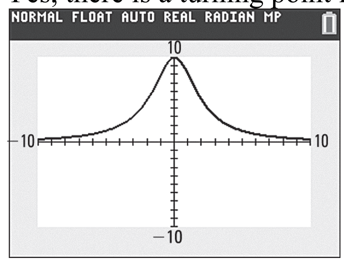
13. $y = \dfrac{9}{x^2 + 1}$

Yes, there is a turning point in this window.

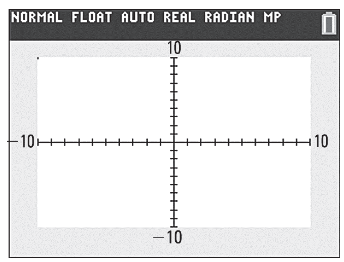


14. $y = \dfrac{40}{x^2 + 4}$

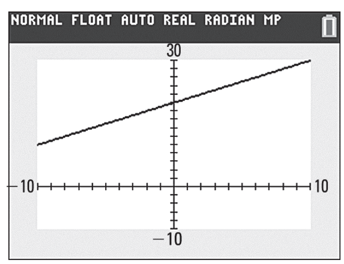
Yes, there is a turning point in this window.



15. a. $y = x + 20$

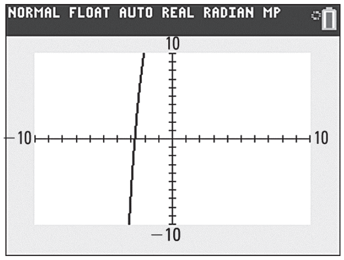


b. $y = x + 20$

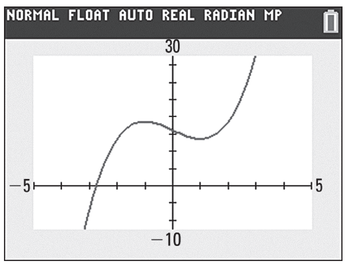


The window in (b) gives a better view.

16. a. $y = x^3 - 3x + 13$

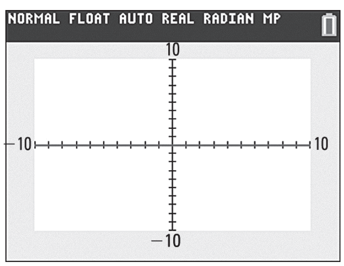


b. $y = x^3 - 3x + 13$

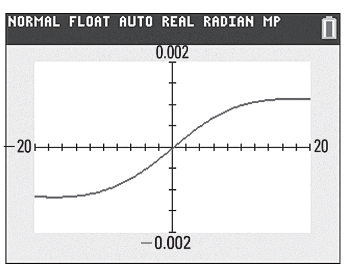


The window in (b) gives a better view.

17. a. $y = \dfrac{0.04(x - 0.1)}{x^2 + 300}$

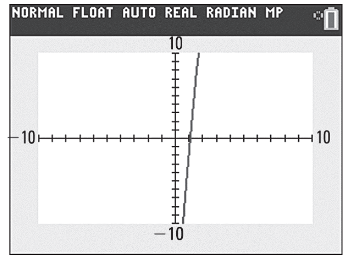


b. $y = \dfrac{0.04(x - 0.1)}{x^2 + 300}$

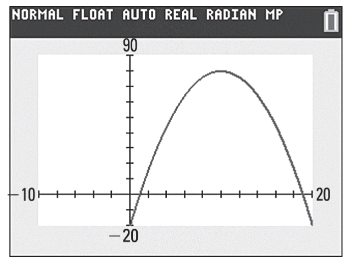


The window in (b) gives a better view.

18. a. $y = -x^2 + 20x - 20$

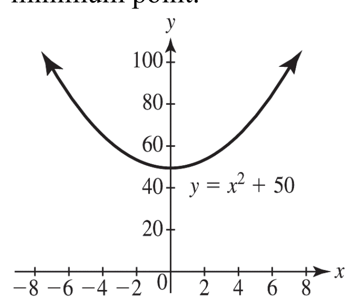


b. $y = -x^2 + 20x - 20$

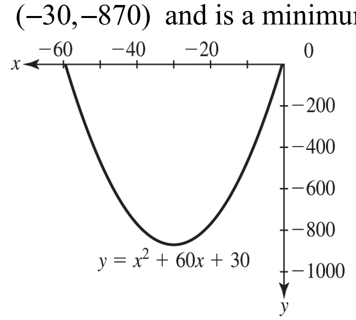


The window in (b) gives a better view.

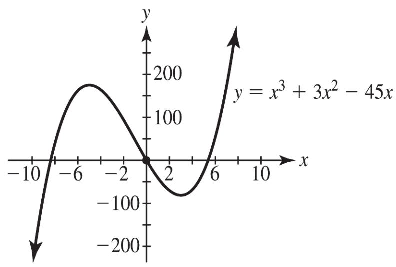
19. When $x = -8$ or $x = 8$, then $y = 114$.
When $x = 0$, then $y = 50$.
For $y = x^2 + 50$, let y vary from -5 to 100.
The turning point is at $(0, 50)$ and is a minimum point.



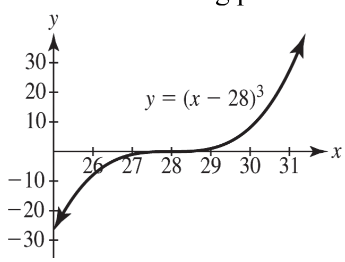
20. When $x = -60$, then $y = 30$. When $x = 0$, then $y = 30$. When $x = -30$, then $y = -870$.
For $y = x^2 + 60x + 30$, let y vary from -1000 to 0. The turning point is at $(-30, -870)$ and is a minimum point.



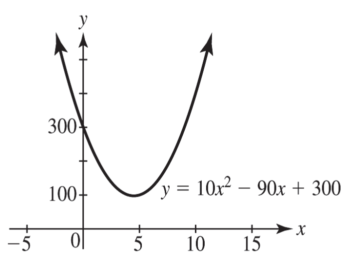
21. When $x = -10$, then $y = -250$.
When $x = 10$, then $y = 850$.
When $x = 0$, then $y = 0$.
For $y = x^3 + 3x^2 - 45x$, let y vary from -200 to 300.
The turning points are at $(-5, 175)$, a maximum, and at $(3, -81)$, a minimum.



22. When $x = 28$, then $y = 0$.
When $x = 25$, then $y = -27$.
When $x = 31$, then $y = 27$.
There is no turning point.

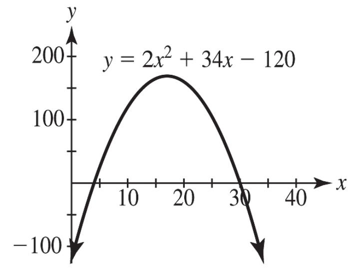


23.



Note that answers for the window may vary.

24. $y = -x^2 + 34x - 120$



Note that answers for the window may vary.

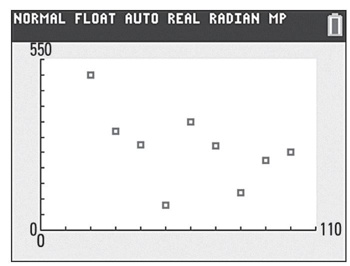
25. $S(t) = 5.2t - 10.5$

t	12	16	28	43
$S(t)$	51.9	72.7	135.1	213.1

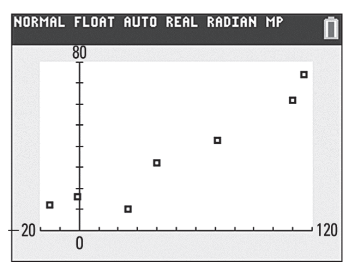
26. $f(q) = 3q^2 - 5q + 8$

q	−8	−5	24	43
$f(q)$	240	108	1616	5340

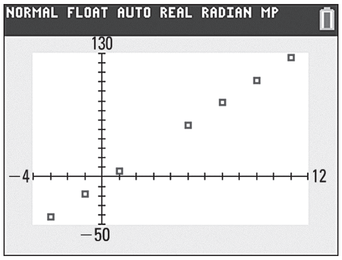
27.



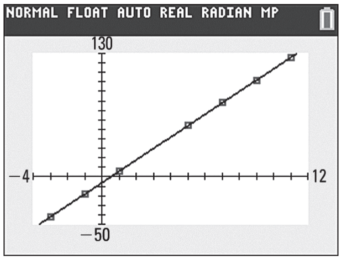
28.



29. a.

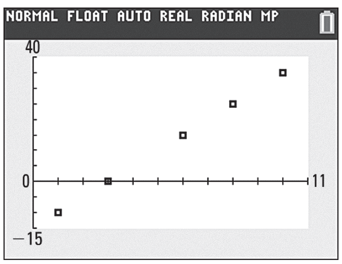


b.

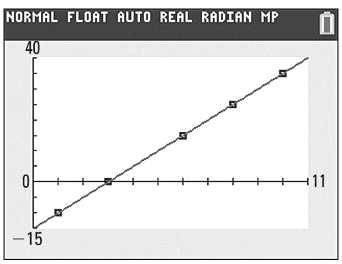


c. Yes; yes

30. a.



b.



c. Yes; yes

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

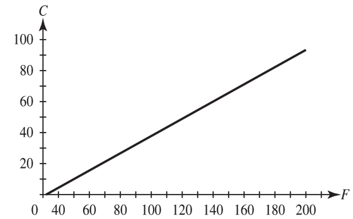
b. $x = 20$ implies 20 years after 2000. Therefore, the answer to part (a) gives the millions of dollars earned in 2020.

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

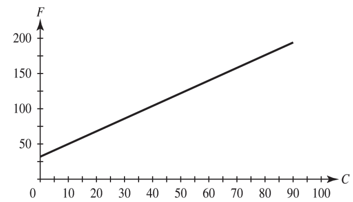
b. In 2010, $x = 10$, and 9950 thousand units or 9,950,000 units are produced.

Exercises 1.2

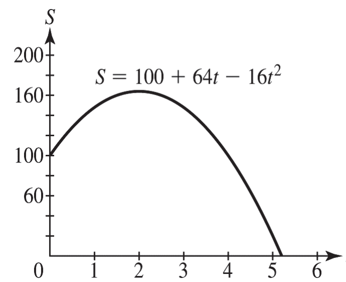
33.



34.



35. a.



b.

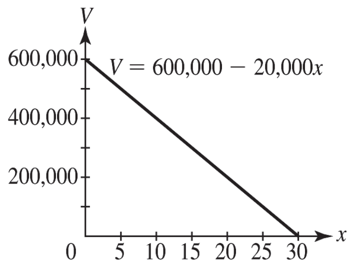
X	Y1
0	100
1	148
2	164
3	148
4	100
5	20
6	-92

X=0

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

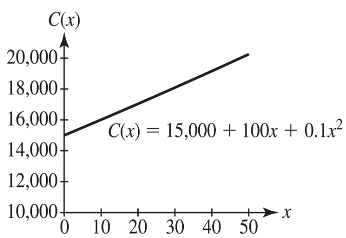
c. From the table in part (b), it appears the maximum height is 164 feet, occurring 2 seconds into the flight of the ball.

36. a.

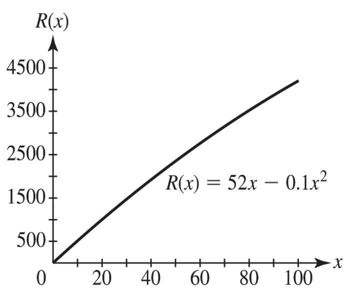


b. $V = 600{,}000 - 20{,}000(10)$
$= 600{,}000 - 200{,}000$
$= \$400{,}000$

37.



38.



39. a. Since x is the number of years after 2010, then $x = 15$ corresponds to 2025 and $x = 20$ corresponds to 2030.

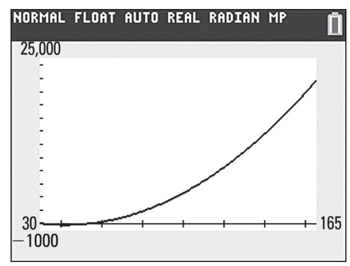
b. $y = 1.31(15)^3 - 22.6(15)^2 + 210(15) - 164$
$= 1.31(3375) - 22.6(225) + 210(15) - 164$
$= 4421.25 - 5085 + 3150 - 164$
$= 2322.25$
In 2025, U.S. revenue from Iot is projected to be approximately \$2322 million.

c. $y = 1.31(20)^3 - 22.6(20)^2 + 210(20) - 164$
$= 1.31(8000) - 22.6(400) + 210(20) - 164$
$= 10{,}480 - 9040 + 4200 - 164$
$= 5476$
In 2030, the U.S. revenue from Iot is projected to be \$5476 million.

40. a. Since x is the number of years after 1950, then $x = 70$ corresponds to 2020.
$P = 0.79(70) + 20.86$
$= 55.3 + 20.86$
$= 76.16$
In 2020, there will be 76.16 million (or 76,160,000) women in the workforce.

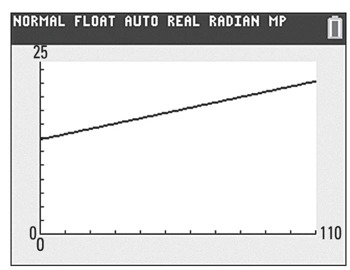
b. $2030 - 1950 = 80$
$P = 0.79(80) + 20.86$
$= 63.2 + 20.86$
$= 84.06$
In 2030, there will be 84.06 million (or 84,060,000) women in the workforce.

41. a.



b. Use the Trace feature.
When $x = 130$, $P = 10{,}984{,}200$.
In 2030, the population of American 85 years and older is predicted to be 10,984,200.

42. a.



b. Year $= x + 1950$
For $x = 0$, Year $= 0 + 1950 = 1950$
For $x = 110$, Year $= 110 + 1950 = 2060$

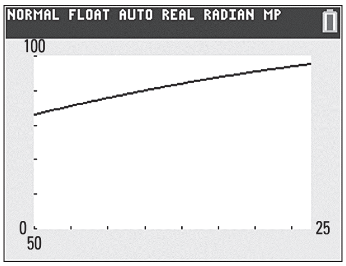
c. Use the Trace feature. When $x = 88$, then $y = 20.6$ years.

43. a $P(22) = -0.021(22)^2 + 1.71(22) + 68.18$
$= -0.021(484) + 1.71(22) + 68.18$
$= -10.164 + 37.62 + 68.18$
$= 95.636$
In 2022, 95.636% of U.S. residents used the internet.

b. $x_{\min} = 0;\ x_{\max} = 25$

c. $y_{\max} = 100$

d.



44. a. $t = \text{Year} - 2000$
For 2012, $t = 2012 - 2000 = 12$
For 2016, $t = 2016 - 2000 = 16$
For 2020, $t = 2020 - 2000 = 20$

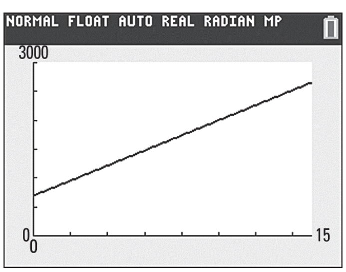
b. $S = f(18)$ gives the value of S in 2018.

$f(18) = 2.4807(18)^3 - 52.251(18)^2$
$+528.68(18) + 5192.6 \approx 12{,}247$

In 2018, the federal tax per capita is approximately $12,247.

c. $x_{\min} = 2000 - 2000 = 0$
$x_{\max} = 2020 - 2000 = 20$

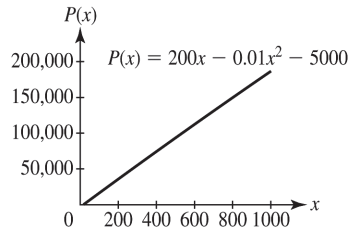
45. a.



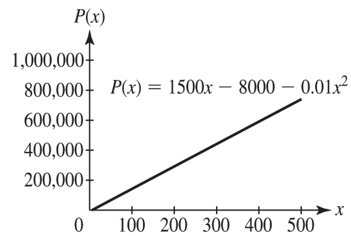
b. $y = 130.7(13) + 699.7 = 2398.8$
In 2023, the balance of federal direct student loans will be $2398.8 billion.

c. $y = 130.7(19) + 699.7 = 3183$
In 2029, the balance of federal direct student loans will be $3183 billion.

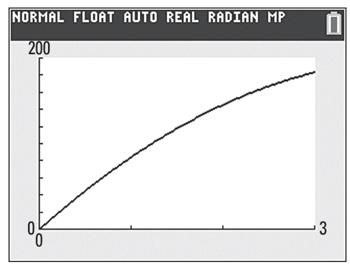
46.



47.



48. a.

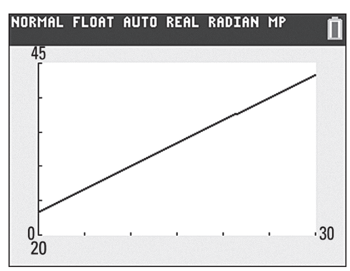


b Amount of drug decreases over this period.

49. a. $x = \text{Year} - 2000$
For 2000, $x = 2000 - 2000 = 0$
For 2030, $x = 2030 - 2000 = 30$

b. For $x = 0$, $y = 0.665(0) + 23.4 = 23.4$
For $x = 30$, $y = 0.665(30) + 23.4 = 43.35$

c.



50. a. $x = \text{Year} - 1980$

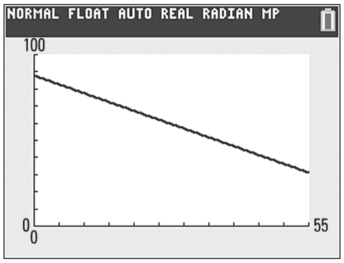
For 2000, $x = 1980 - 1980 = 0$

For 2030, $x = 2035 - 1980 = 55$

b. For $x = 0$, $y = -1.03(0) + 88.1 = 88.1$

For $x = 35$, $y = -1.03(35) + 88.1 = 52.05$

c.

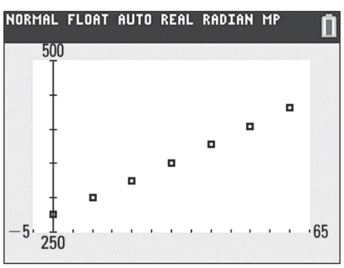


51. a. 299.9 million, or 299,900,000

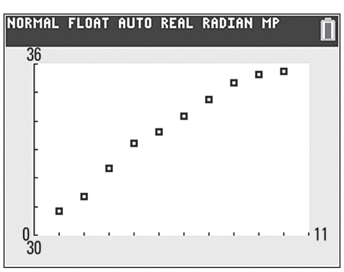
b.

Years after 2000	Population (millions)
0	275.3
10	299.9
20	324.9
30	351.1
40	377.4
50	403.7
60	432.0

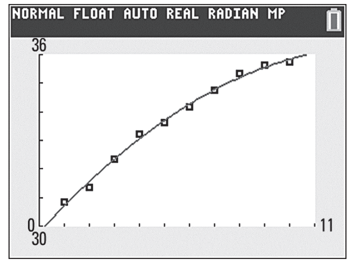
c.



52. a.

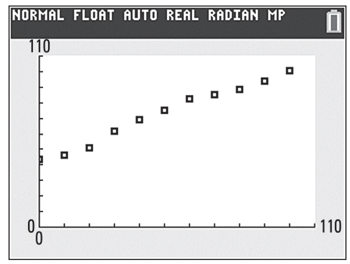


52. b.

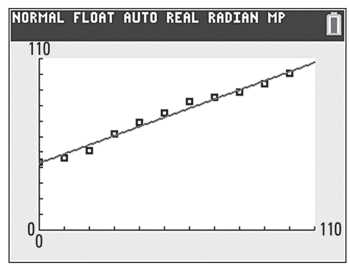


c. Yes

53. a.

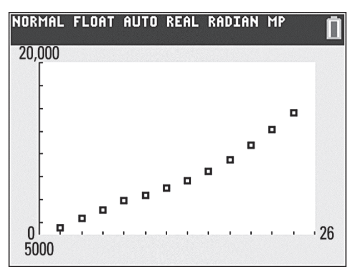


b.

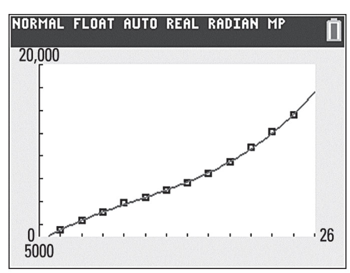


c. Yes

54. a.



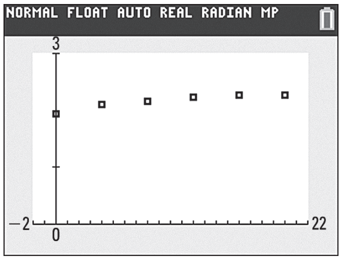
b.



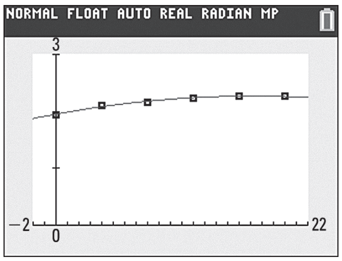
c. Yes

55. a. In 2026, the crude oil production will be 2.26 billion barrels.

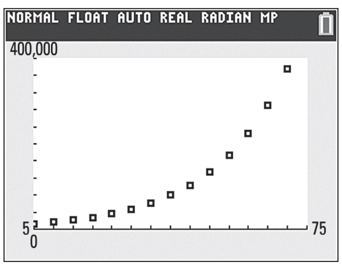
b.



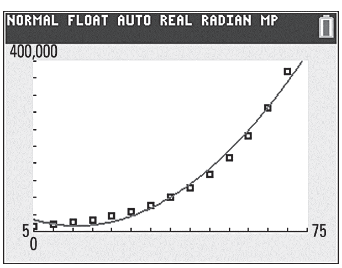
c.



56. a.



b.



c. $y = 117(46)^2 - 3792(46)x + 45,330$

$y = 247,572 - 174,432 + 45,330$

$y = 118,470$

Skills Check 1.3

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

a. The function $y = 3x^2 + 2$ is not linear. It has a 2nd degree (squared) term.

b. The function $3x + 2y = 12$ is linear.

c. The function $y = \frac{1}{x} + 2$ is not linear. The x-term is in the denominator of the fraction.

2. No. A vertical line is not a function.

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

4. $m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{4-(-10)}{8-8} = \frac{14}{0} = \text{undefined}$

5. The line passes through $(-2,0)$ and $(0,4)$.

The slope is $m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{4-0}{0-(-2)} = \frac{4}{2} = 2.$

6. Since the line is horizontal, the slope $m = 0$.

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

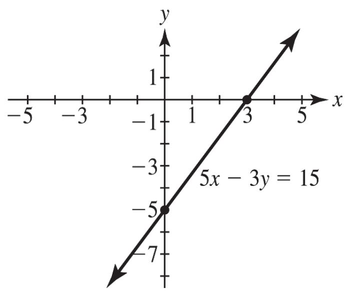
$$5x - 3(0) = 15$$
$$5x = 15$$
$$x = 3$$

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

$$5(0) - 3y = 15$$
$$-3y = 15$$
$$y = -5$$

x-intercept: $(3,0)$; y-intercept: $(0,-5)$

7. **b.**



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

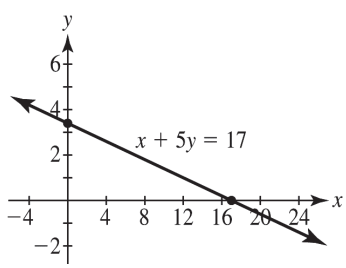
$$x + 5(0) = 17$$
$$x = 17$$

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

$$0 + 5y = 17$$
$$5y = 17$$
$$y = \frac{17}{5}$$

x-intercept: $(17, 0)$; y-intercept: $\left(0, \frac{17}{5}\right)$

b.



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

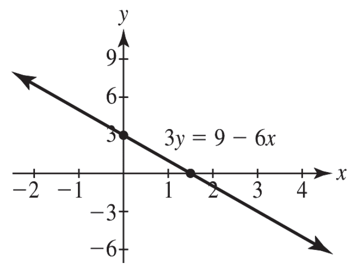
$$3(0) = 9 - 6x$$
$$0 = 9 - 6x$$
$$6x = 9$$
$$x = \frac{3}{2}$$

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

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

x-intercept: $\left(\frac{3}{2}, 0\right)$; y-intercept: $(0, 3)$

9. **b.**



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

$$0 = 9x$$
$$x = 0$$

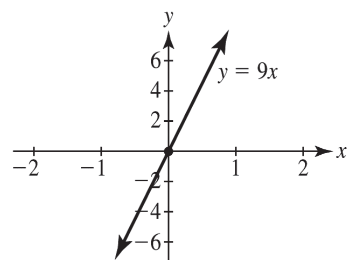
y-intercept: Let $x = 0$ and solve for y.

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

x-intercept: $(0, 0)$; y-intercept: $(0, 0)$

The origin, $(0, 0)$, is both an x- and y-intercept. To graph, use the slope, $m = 9$, or find another point on the line. For example, $(1, 9)$ or $(-1, -9)$.

b.



11. If a line is horizontal, then its slope is 0.
If a line is vertical, then its slope is undefined.

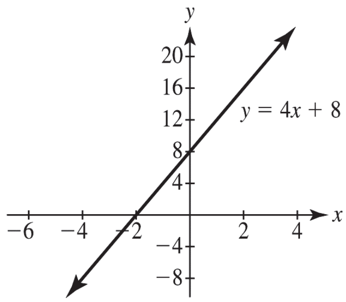
12. Since slope is undefined, the line is vertical.

13. **a.** Positive. The graph is rising.
b. Undefined. The line is vertical.

14. **a.** Negative. The graph is falling.
b. Zero, 0. The line is horizontal.

15. a. $m = 4, b = 8$

b.



16. a. $3x + 2y = 7$

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

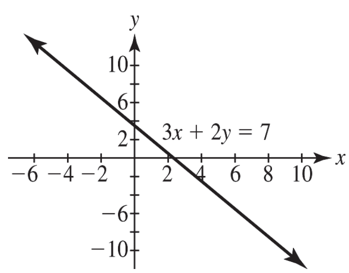
$$\frac{2y}{2} = \frac{-3x+7}{2}$$

$$y = \frac{-3x+7}{2}$$

$$y = -\frac{3}{2}x + \frac{7}{2}$$

$$m = -\frac{3}{2},\ b = \frac{7}{2}$$

b.

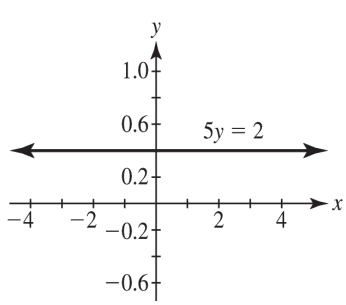


17. a. $5y = 2$

$$y = \frac{2}{5}$$

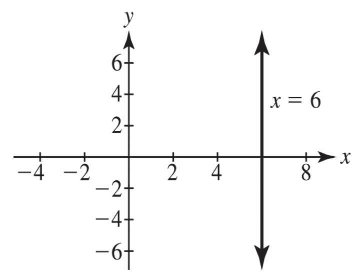
This is a horizontal line. $m = 0,\ b = \frac{2}{5}$

b.



18. a. $x = 6$ This is a vertical line.
The slope is undefined.
There is no y-intercept.

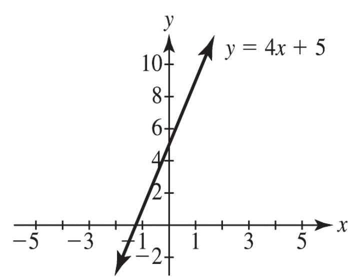
b.



19. a. $m = 4,\ b = 5$

b. Rising. The slope is positive

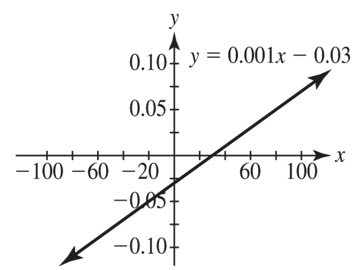
c.



20. a. $m = 0.001,\ b = -0.03$

b. Rising. The slope is positive.

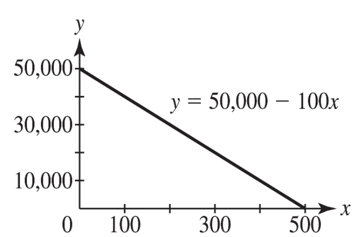
c.



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

b. Falling. The slope is negative.

c.



22. Steepness refers to the vertical change compared to the horizontal change between any two points on a line, regardless of the direction. A steeper line would have slope of greater absolute value. The slope in #19 is 4, #20 is 0.001, and #21 is -100. Comparing the absolute values, the order of increasing steepness is #20, #19, #21.

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

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

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

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

27. For a linear function, the rate of change is equal to the slope.

$$m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{-7-3}{4-(-1)} = \frac{-10}{5} = -2$$

28. For a linear function, the rate of change is equal to the slope.

$$m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{3-1}{6-2} = \frac{2}{4} = \frac{1}{2}$$

29. **a.** The identity function is $y = x$. Graph (ii) represents the identity function.

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

30. The slope of the identity function is 1.

31. **a.** The slope of a constant function is 0.

b. The rate of change of a constant function equals the slope, which is 0.

32. The rate of change of the identity function equals the slope, which is 1.

Exercises 1.3

33. **a.** Yes, the function is linear since it has the form $y = mx + b$.

The independent variable is *t*, the number of years after 2015.

b. $m = 22.71$

c. $b = 183.6$

34. No. This is not a linear function since it does not fit the form $y = mx + b$.

35. **a.** The function is linear since it is written in the form $y = mx + b$.

b. $m = 0.077$ The life expectancy is projected to increase by approximately 0.1 year per year.

36. **a.** The slope is 130.7.

b. The balance of federal direct student loans is projected to increase at a rate of $130.7 billion per year.

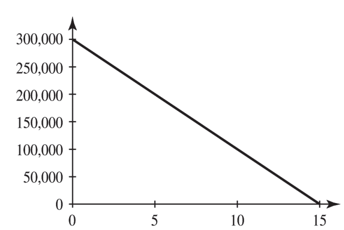
37. **a.** $b = 300{,}000$; At the beginning of the 15 years, the building is worth $300,000.

b.

$$0 = 300{,}000 - 20{,}000x$$
$$20{,}000x = 300{,}000$$
$$x = 15$$

The value of the building is $0 at the end of the 15 years.

c.



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

$R = 39{,}000 - 0.06(0)$

$R = 39{,}000$

The R-intercept is $(0, 39{,}000)$.

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

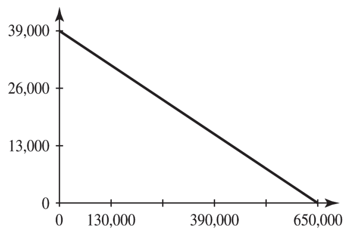
$0 = 39{,}000 - 0.06x$

$0.06x = 39{,}000$

$x = 650{,}000$

The x-intercept is $(650{,}000, 0)$.

c.



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

$0 = 3500 - 70x$

$70x = 3500$

$x = 50$

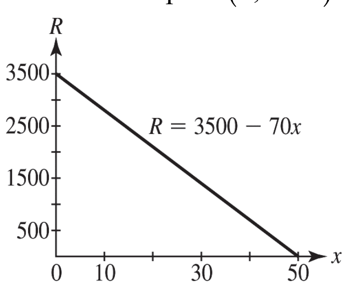
The x-intercept is $(50, 0)$.

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

$R = 3500 - 70(0)$

$R = 3500$

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



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

$10R + 4(0) = 200$

$10R = 200$

$R = 20$

The R-intercept is $(0, 20)$.

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

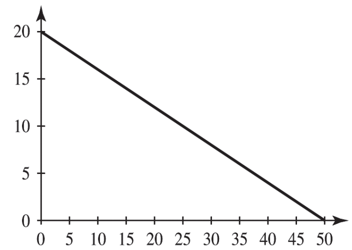
$10(0) + 4x = 200$

$4x = 200$

$x = 50$

The x-intercept is $(50, 0)$.

40. b.



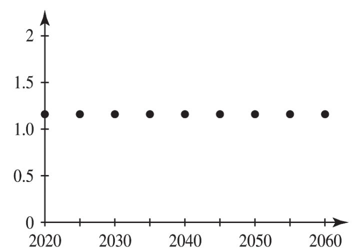
41. a. Data can be modeled by a constant function. Every input x yields the same output y.

b. $y = 11.81$

c. A constant function has slope of 0.

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

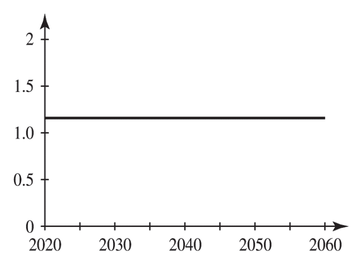
42. a.



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

c. $y = 1.16$

d.



43. a. $m = 0.328$

b. From 2010 through 2040, the disposable income is projected to increase by $328 million per year.

44. The average rate of growth over this period of time is 0.465 percentage points per year.

$$\frac{34.3 - 15.7}{2050 - 2010} = 0.465$$

45. a. The *P*-intercept is 20.86. Approximately 21 million women were in the workforce in 1950.

b. $m = 0.79$

c. The rate of change of the number of women in the workforce is 790 thousand per year.

46. a. The slope is 0.063.

b. From 2000 to 2050, the world population is projected to grow by 63 million per year.

47. a. $m = 0.057$

b. From 1990 to 2050, the percent of the U.S. population that is black increased by 0.057 percentage point per year.

48. a. Solve for *p*. $m = \frac{6}{11}$

$$33p - 18d = 496$$
$$33p = 18d + 496$$
$$p = \frac{18d + 496}{33}$$
$$p = \frac{6}{11}d + \frac{496}{33}$$

b. For every one foot increase in depth, there is a $\frac{6}{11}$ pound per square inch increase in pressure. More generally, as depth increases, pressure increases.

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

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

50. a. $m = 0.770$; $b = 1.271$

b. The *y*-intercept represents the percent of U.S. sales of electric or plug-in hybrid electric vehicles in 2017.

c. The slope represents the percent change in the number of U.S. sales of electric or plug-in hybrid electric vehicles.

51. a. $m = 9.32$; $b = 989$

b. The population of China aged 15 years and older is projected to increase by 9.32 million per year.

52. a. $m = 14.6$
The rate of growth in spending is $14.6 billion during this period.

b. $2025 - 2018 = 7$

$$y = 14.6(7) + 1618.6$$
$$y = 102.2 + 1618.6$$
$$y = 1720.8$$

The projected global telecom spending for 2025 is $1720.8 billion.

c. $b = 1618.6$
In 2015, the global telecom spending was estimated to be $1618.6 billion.

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

b. The rate of change is –$61,000 per year.

54. a. $m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{100.3 - 43.8}{2050 - 1950}$
$= \frac{56.5}{100} = 0.565$

b. The number of men in the workforce increased by 0.565 million (or 565,000) each year from 1950 to 2050.

55. Marginal profit is the rate of change of the profit.

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

The marginal profit is \$58 per unit.

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

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

The marginal cost is \$2.80 per unit.

57. a. $m = 0.56$

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

c. The cost will increase by \$0.56 for each additional ball produced in a month.

58. a. $m = 98$

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

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

59. a. $m = 1.60$

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

c. The revenue will increase by \$1.60 for each additional ball sold in a month.

60. a. $m = 198$

b. The marginal revenue is \$198 per unit.

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

61. $m = 19$

The marginal profit is \$19 per unit.

62. $m = 939$

The marginal profit is \$939 per unit.

Skills Check 1.4

1. $m = 4,\ b = \frac{1}{2}$

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

2. $m = 5,\ b = \frac{1}{3}$

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

3. $m = \frac{1}{3},\ b = 3$

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

4. $m = -\frac{1}{2},\ b = -8$

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

5.

$$\begin{aligned} y - y_1 &= m(x - x_1) \\ y - (-6) &= -\frac{3}{4}(x - 4) \\ y + 6 &= -\frac{3}{4}x + 3 \\ y &= -\frac{3}{4}x - 3 \end{aligned}$$

6.

$$\begin{aligned} y - y_1 &= m(x - x_1) \\ y - 3 &= -\frac{1}{2}(x - (-4)) \\ y - 3 &= -\frac{1}{2}(x + 4) \\ y - 3 &= -\frac{1}{2}x - 2 \\ y &= -\frac{1}{2}x + 1 \end{aligned}$$

7. $x = 9$

8. $y = -10$

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

$y - y_1 = m(x - x_1)$
$y - 7 = 1(x - 4)$
$y - 7 = x - 4$
$y = x + 3$

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

$y - y_1 = m(x - x_1)$
$y - 6 = 1(x - 2)$
$y - 6 = x - 2$
$y = x + 4$

11. $m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{2-2}{-3-5} = \frac{0}{-8} = 0$

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

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

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

13. With the given intercepts, the line passes through the points $(-5,0)$ and $(0,4)$.

$m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{4-0}{0-(-5)} = \frac{4}{5}$

$y - y_1 = m(x - x_1)$
$y - 0 = \frac{4}{5}(x - (-5))$
$y = \frac{4}{5}(x + 5)$
$y = \frac{4}{5}x + 4$

14. With the given intercepts, the line passes through the points $(4,0)$ and $(0,-5)$.

$m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{-5-0}{0-4} = \frac{-5}{-4} = \frac{5}{4}$

$y - y_1 = m(x - x_1)$
$y - 0 = \frac{5}{4}(x - 4)$
$y = \frac{5}{4}(x - 4)$
$y = \frac{5}{4}x - 5$

15. $3x + y = 4$
$y = -3x + 4$
$m = -3$

Since the new line is parallel to the given line, the slopes of both lines are equal.

$y - y_1 = m(x - x_1)$
$y - (-6) = -3(x - 4)$
$y + 6 = -3x + 12$
$y = -3x + 6$

16. $2x + y = -3$
$y = -2x - 3$
$m = -2$

Since the new line is parallel to the given line, the slopes of both lines are the same.

$y - y_1 = m(x - x_1)$
$y - (-3) = -2(x - 5)$
$y + 3 = -2x + 10$
$y = -2x + 7$

17. $2x + 3y = 7$
$3y = -2x + 7$
$\frac{3y}{3} = \frac{-2x+7}{3}$
$y = -\frac{2}{3}x + \frac{7}{3}$
$m = -\frac{2}{3}$

Since the new line is perpendicular to the given line, the slope is $m_{\perp} = -\frac{1}{m}$, where m is the slope of the given line.

17. (continued)

$$m_\perp = -\frac{1}{m} = -\frac{1}{\left(-\frac{2}{3}\right)} = \frac{3}{2}$$

$$y - y_1 = m(x - x_1)$$
$$y - 7 = \frac{3}{2}(x - (-3))$$
$$y - 7 = \frac{3}{2}x + \frac{9}{2}$$
$$y = \frac{3}{2}x + \frac{23}{2}$$

18. $3x + 2y = -8$

$$2y = -3x - 8$$
$$\frac{2y}{2} = \frac{-3x - 8}{2}$$
$$y = -\frac{3}{2}x - 4$$
$$m = -\frac{3}{2}$$

Since the new line is perpendicular to the given line, the slope is $m_\perp = -\frac{1}{m}$, where m is the slope of the given line.

$$m_\perp = -\frac{1}{m} = -\frac{1}{\left(-\frac{3}{2}\right)} = \frac{2}{3}$$

$$y - y_1 = m(x - x_1)$$
$$y - 5 = \frac{2}{3}(x - (-4))$$
$$y - 5 = \frac{2}{3}(x + 4)$$
$$y - 5 = \frac{2}{3}x + \frac{8}{3}$$
$$y = \frac{2}{3}x + \frac{23}{3}$$

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

$$y - y_1 = m(x - x_1)$$
$$y - 13 = 3(x - 4)$$
$$y - 13 = 3x - 12$$
$$y = 3x + 1$$

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

$$y - y_1 = m(x - x_1)$$
$$y - 7 = -3(x - (-4))$$
$$y - 7 = -3(x + 4)$$
$$y - 7 = -3x - 12$$
$$y = -3x - 5$$

21. $m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{(-5) - (-5)}{1 - 0} = \frac{0}{1} = 0$

$$y - y_1 = m(x - x_1)$$
$$y - (-5) = 0(x - 1)$$
$$y + 5 = 0$$
$$y = -5$$

22. $m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{1 - 0}{3 - 3} = \frac{1}{0} = \text{undefined}$

Slope is undefined and the line is vertical. Each point on the line has an *x*-coordinate of 3. The equation of the line is $x = 3$.

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

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

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

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

25. For a linear function, the rate of change is equal to the slope. Therefore, $m = \frac{2}{3}$.

$$\begin{aligned} y - y_1 &= m(x - x_1) \\ y - 9 &= \frac{2}{3}(x - 3) \\ y - 9 &= \frac{2}{3}x - 2 \\ y &= \frac{2}{3}x + 7 \end{aligned}$$

26. For a linear function, the rate of change is equal to the slope. Therefore, $m = -\frac{1}{5}$.

$$\begin{aligned} y - y_1 &= m(x - x_1) \\ y - 12 &= -\frac{1}{5}(x - (-2)) \\ y - 12 &= -\frac{1}{5}x - \frac{2}{5} \\ y &= -\frac{1}{5}x + \frac{58}{5} \end{aligned}$$

27. $$\begin{aligned} \frac{f(b) - f(a)}{b - a} &= \frac{f(2) - f(-1)}{2 - (-1)} \\ &= \frac{(2)^2 - (-1)^2}{2 + 1} \\ &= \frac{4 - 1}{3} \\ &= \frac{3}{3} \\ &= 1 \end{aligned}$$

The average rate of change is 1.

28. $$\begin{aligned} \frac{f(b) - f(a)}{b - a} &= \frac{f(2) - f(-1)}{2 - (-1)} \\ &= \frac{(2)^3 - (-1)^3}{2 + 1} \\ &= \frac{8 + 1}{3} \\ &= \frac{9}{3} \\ &= 3 \end{aligned}$$

The average rate of change is 3.

29. $$\begin{aligned} \frac{f(b) - f(a)}{b - a} &= \frac{f(1) - f(-2)}{1 - (-2)} \\ &= \frac{-2 - 7}{1 + 2} \\ &= \frac{-9}{3} \\ &= -3 \end{aligned}$$

30. $$\begin{aligned} \frac{f(b) - f(a)}{b - a} &= \frac{f(2) - f(-1)}{2 - (-1)} \\ &= \frac{-4 - 2}{2 + 1} \\ &= \frac{-6}{3} \\ &= -2 \end{aligned}$$

31. $$\begin{aligned} y - y_1 &= m(x - x_1) \\ y - (-10) &= -3(x - 1) \\ y + 10 &= -3x + 3 \\ y &= -3x - 7 \end{aligned}$$

The y-intercept is $b = -7$.

32. $$\begin{aligned} y - y_1 &= m(x - x_1) \\ y - 8 &= -\frac{3}{2}(x - (-2)) \\ y - 8 &= -\frac{3}{2}x - 3 \\ y &= -\frac{3}{2}x + 5 \end{aligned}$$

The y-intercept is $b = 5$.

33. $$\begin{aligned} f(x + h) &= 45 - 15(x + h) \\ &= 45 - 15x - 15h \end{aligned}$$

$$\begin{aligned} &f(x + h) - f(x) \\ &= 45 - 15x - 15h - [45 - 15x] \\ &= 45 - 15x - 15h - 45 + 15x \\ &= -15h \end{aligned}$$

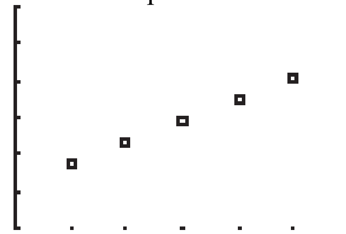
$$\frac{f(x + h) - f(x)}{h} = \frac{-15h}{h} = -15$$

34. $f(x+h)=32(x+h)+12$
$=32x+32h+12$
$f(x+h)-f(x)$
$=32x+32h+12-[32x+12]$
$=32x+32h+12-32x-12$
$=32h$
$\dfrac{f(x+h)-f(x)}{h}=\dfrac{32h}{h}=32$

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

36. $f(x+h)=3(x+h)^2+1$
$=3(x^2+2xh+h^2)+1$
$=3x^2+6xh+3h^2+1$
$f(x+h)-f(x)$
$=3x^2+6xh+3h^2+1-[3x^2+1]$
$=3x^2+6xh+3h^2+1-3x^2-1$
$=6xh+3h^2$
$\dfrac{f(x+h)-f(x)}{h}=\dfrac{6xh+3h^2}{h}$
$=\dfrac{h(6x+3h)}{h}$
$=6x+3h$

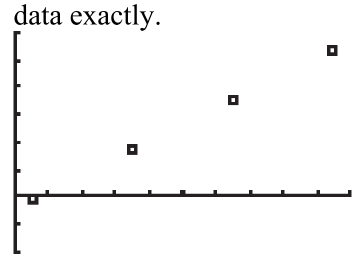
37. a. Difference in y-coordinates is always 30. Difference in x-coordinates is always 10. See scatter plot. A line fits the data exactly.



[0, 60] by [500, 800]

b. $m=\dfrac{y_2-y_1}{x_2-x_1}=\dfrac{615-585}{20-10}=\dfrac{30}{10}=3$
$y-y_1=m(x-x_1)$
$y-585=3(x-10)$
$y-585=3x-30$
$y=3x+555$

38. a. Difference in y-coordinates is always 9. Difference in x-coordinates is always 6. Consider the scatter plot. A line fits the data exactly.



[0, 20] by [–10, 30]

b. $m=\dfrac{y_2-y_1}{x_2-x_1}=\dfrac{26.5-17.5}{19-13}=\dfrac{9}{6}=\dfrac{3}{2}$
$y-y_1=m(x-x_1)$
$y-26.5=\dfrac{3}{2}(x-19)$
$y-26.5=\dfrac{3}{2}x-\dfrac{57}{2}$
$y=\dfrac{3}{2}x-2$