Section 1.1
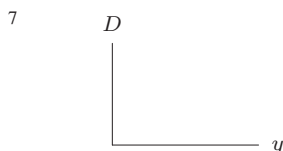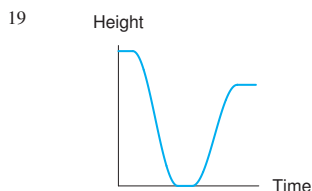
S1 $(2/3)c$

S3 $6\pi r^2$

S5 $51/2$

S7 $3/2$

S9 $A = (-2, 8)$

1 (a) 2
 (b) 2
 (c) About 12 hours

3 $w = f(c)$

5

Cost ($)
q (items)

7

D
y

9 (a) 4
 (b) 3
 (c) 2
 (d) 2 and 4

11 2.9

13 0, 4, 8

15 (a) w
 (b) $(-4, 10)$
 (c) $(6, 1)$

17 (a) Yes
 (b) No

19

Height
Time

21 (a) 100.3 m. own phones in 2000
 (b) 20 m. own phones a years after 1990
 (c) b m. own phones in 2010
 (d) n m. own phones t years after 1990

23 (a) Most: Hannah; least: Madison
 (b) Most: Madison; least: Alexis

25 (a) 10.71 gallons
 (b) 0.25 gallons
 (c) 55 mph

27 (a) 72π ft^3
 (b) 45π ft^3
 (c) $V(h) = 9\pi h$

29 (a) 69°F
 (b) July 17 and 20
 (c) Yes

(d) No

31 (a) No
 (b) Yes
 (c) In 1981, record was 3 min 47.33 sec
 (d) 1967, record of 3 min 51.1 sec

33 (a) $x + y$
 (b) $0.15x + 0.18y$
 (c) $(15x + 18y)/(x + y)$

35 $A(r) = \pi r^2$
 21%

37 (b) $C = 2 + (0.5)l$

Section 1.2

S1 -2

S3 -2

S5 -1

S7 $-3x^2 - 4ax - a^2$

S9 $x + y$

1 (a) 80/3 CDs per year
 (b) -20 CDs per year
 (c) 0 CDs per year

3 Decreasing

5 0.513

7 0.513

9 (a) Negative
 (b) Positive

11 $F(-2) > F(2)$

13 (a) $A = (10, 30)$
 $B = (30, 40)$
 $C = (50, 90)$
 $D = (60, 40)$
 $E = (90, 40)$

 (b) Point F is on the graph.
 (c) Increasing: 6–21,
 36–51, 66–81
 (d) Decreasing: 22–35,
 52–65, 82–96

15 (a) 2
 (b) Increasing
 (c) Increasing everywhere

$g(x)$
x
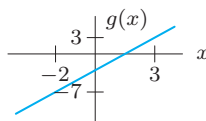
17 (a) Town B
 (b) Town A

19 24.5 degrees/minute

21 (a) 162 calories
 (b) Swimmer
 (c) Increases

23 (a) 9
 (b) $\dfrac{n - k}{m - j}$
 (c) $6x + 3h$

25 (a) 10, 10, 10, 10, 7, 1
 (b) 30, 30.5, 53.6, 33.9, 15.5, -5
 (c) No; $\Delta G/\Delta t$ not constant
 (d) Recycling and composting program in US

Section 1.3

S1 $f(0) = 5, f(3) = 7$

S3 5

S5 $y = 3; x = 3/4$

S7 $7/2, -2$

S9 $-ab + a + 3, a - 3$

1 Not linear

3 No

5 Yes

7 (a) $y = 7 + 2x$
 (b) $y = 8 - 15x$

9 Vert int: 54.25 thousand; Slope: $-2/7$ thousand/yr

11 Vert int: $-\$3000$; Slope: $\$0.98$/item

13 (a) $r = f(v)$ could be linear
 (b) $\$5$ increase/mph
 (c)

r (dollars)
$r = f(v)$
v (mph)

15 $V = 21{,}500 - 3200t$

17 (b)

Cost (dollars)
x (cups)
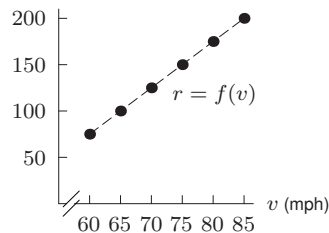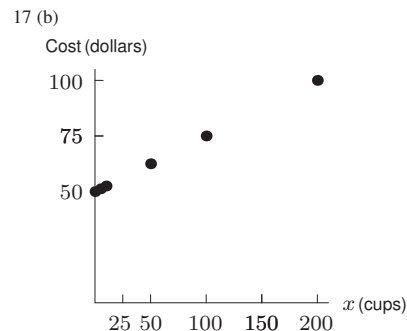
 (c) 0.25
 (d) Start-up cost

19 $\pi(n) = -10{,}000 + 127n$

21 $c = 4000 + 80r$

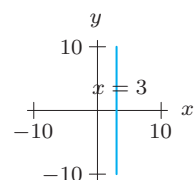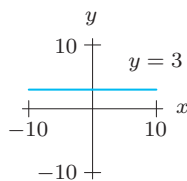23 (a) Radius and circumference
 (c) 2π

25 (a) No
 (b) Looks linear

T
d
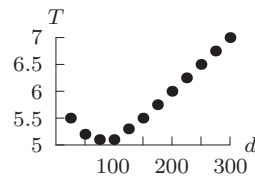
(c) $\Delta T/\Delta d = 0.01°\text{C/meter}$

27 (a) $T = \$1900$
(b) $C = 7$
(d) Twelve credits
(e) Fixed costs that do not depend on the number of credits taken

29 (a) $r = 5/2, s = 16$
(b) $k = 0.2, j = -3$

33 No

Section 1.4

S1 $y = 26$

S3 $x = 2$

S5 $y = -17/16$

S7 $F = (9/5)C + 32$

S9 $x = (c - ab)/(2a)$

1 $y = 4/5 - x$

3 $y = 180 - 10x$

5 $y = -0.3 + 5x$

7 $y = -40/3 - 2/3x$

9 $y = 21 - x$

11 Yes; $F(P) = 13 + (-1/8)P$

13 Yes; $C(r) = 0 + 2\pi r$

15 Yes; $f(x) = n^2 + m^2 x$

17 $y = 8 + 3x$

19 $y = (11 + 2x)/3$

21 $y = 0.03 + 0.1x$

23 $f(x) = 3 - 2x$

25 $q = 2500 - 2000p$

27 $y = 459.7 + 1x$

29 $u = (1/12)n$

31 $f(x) = -12.5 - 1.5x$

33 $h(t) = 12,000 + 225t$

35 (a) $\$11,375$
(b) $\$125$
(c) $\$5$

37 $C(n) = 10,500 + 5n$

39 (b) $v = 40 - 32t$

41 (a) $q = 210 - 50p$

43 $y = -4 + 4x$

45 $y = \frac{16+5\sqrt{7}}{2+\sqrt{7}} - \frac{3}{2+\sqrt{7}}x$ or
$y = (1 + 2\sqrt{7}) + (2 - \sqrt{7})x$

47 (a) $p = 0.1t - 1$, and $t \geq 10$
(b) 11
(d) $t = 10p + 10$
(e) 2 hours 40 minutes

49 (a) $i(x) = 2.5x$
(b) $i(0) = 0$

51 $w(r) = \pi x^2 - s\sqrt{x} + (-3x - 4s)r$;
$b = \pi x^2 - s\sqrt{x}; m = -3x - 4s$

53 (a) $r = 0.005H - 0.03$
(b) $S = 200$

Section 1.5

S1 $x = -2, y = 5$

S3 No solution

S5 $x = 7, y = 4$

S7 $x = 3/2, y = 3/2$

1 (a) (V)
(b) (VI)
(c) (I)
(d) (IV)
(e) (III)
(f) (II)

5 (a)

(b) Yes ($y = 3 + 0x$), No

7 Perpendicular

9 Neither

11 Parallel

13 $y = 6 - (3/5)x$

15 Parallel line:
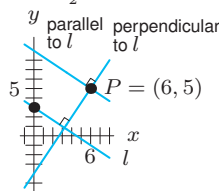$y = -4x + 9$
Perpendicular line:
$y = 0.25x + 4.75$

17 $(1, 0)$

19 (a) 5 years

21 (a) $y = 9 - \frac{2}{3}x$
(b) $y = -4 + \frac{3}{2}x$
(c)

23 (a) $P = (a, 0)$
(b) $A = (0, b), B = (-c, 0)$
$C = (a + c, b), D = (a, 0)$

27 $3 < \beta < 6$

29 (a) $y = -\sqrt{3}x$
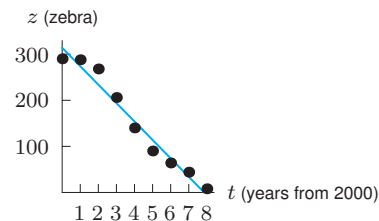(b) $y = (1/\sqrt{3})x + 4/\sqrt{3}$

31 $y = x/3 + 2/3$.

Section 1.6

1 $r = 0.93$ is reasonable.

3 $r = 1$ is not reasonable.

5 $r = 1$ is not reasonable.

7 (a) $r = 1$
(b) $r = 0.7$
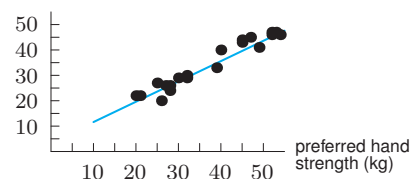
(c) $r = 0$
(d) $r = -0.98$
(e) $r = -0.25$
(f) $r = -0.5$

9 (a) and (b)

(c) $z = -40t + 314$
(e) Strong negative correlation ($r = -0.983$)

11 (a)

(c) $y = 3.623 + 0.825x$
(d) ≈ 34
(e) ≈ 40

Chapter 1 Review

1 Neither

3 Both

5 Neither

7 (a)

x	0	1	2	3
$f(x)$	10	5	2	1

(b) $x = 0$; smallest x-value

9 (a) #2
(b) #1, #3
(c) #3

11 (a) Owens: 12 yards/sec   horse: 20 yards/sec
(b) 6 seconds

13 Yes

15 $f(t) = 2.2 - 1.22t$

17 (a) (ii)
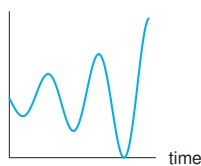(b) (iii)
(c) (i)

19 (a) $y = 3 + 4x$
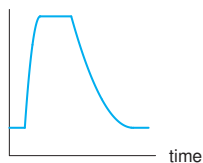(b) $y = 5 - 2x$

21 Neither

23 Perpendicular

25 120

27 500 m

29 distance of bug from light

time

31 temperature

time

33 $T(d) = d/5 + (10 - d)/8$

35 $s = 1440 - w$
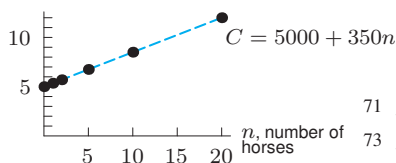
37 (a)   (i) 1/2

     (ii) 1/2

     (iii) 1/2

  (b) Always 1/2

39 (a) $0°$C/meter

  (b) $-0.008°$C/meter

  (c) $0.009°$C/meter.

41 (a) $5350, $5700, $6750,

    $8500, $12,000

C, total cost ($1000s)

$C = 5000 + 350n$

n, number of horses

(b) $C = 5000 + 350n$

(c) $350/horse

43 $h(t) = 254 - 248t$

45 (a) 1000, 990.2, 980.4, 970.6, 960.8

  (b) v decreasing at constant rate

  (c) Slope: -9.8 meter/sec^2

    v-intercept: 1000meters/sec

    t-intercept: 102.04 sec

49 (a) $S = -100 + 100p$

  (c) Yes, $1

  (d) $4

51 $g(x) = -2 - 2x$

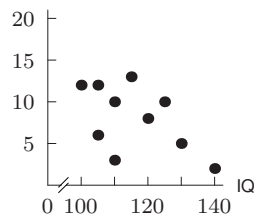53 $y = 2.8 - 0.1x$

55 $d = 60 + 50t$

57 $g(x) = 32 - (3/5)x$

59 (a) $Y_A = 0.37x$

    $Y_B = 13.95 + 0.22x$

    $Y_C = 50$

  (c) $93 < x \le 163$

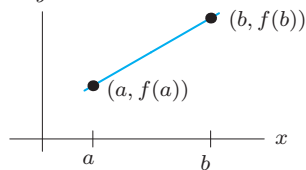61 (a) hours of TV

IQ

(b) $r \approx -1/2$

(c) $y = 27.5139 - 0.1674x$

    $r = -0.5389$
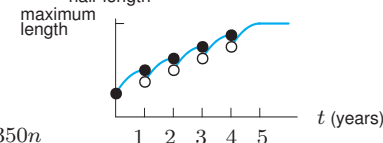
63 (a)

(b) $(f(b) - f(a))/(b - a)$

65 $y = 0.75/(0.75 - 1) - (\sqrt{0.5})^2 x; p = 0.75, r = \sqrt{0.5}$

67 (a) y-intercept: c/q

    x-intercept: c/p

  (b) $-(p/q)$

69 hair length

t (years)

71 $g(x) = 17/5 + 6/(5\pi) \cdot x$

73 $g(54) = 8^{1/5} = \sqrt[5]{8}$

Ch. 1 Understanding

1 False

3 True

5 True

7 True

9 True

11 True

13 True

15 True

17 False

19 False

21 False

23 True

25 True

27 False

29 True

31 False

33 False

35 True

37 False

39 False

41 True

43 False

45 True

47 True

49 False

51 True

53 True

Ch. 1 Skills: Linear Equations

1 $x = 5$

3 $z = 11/2$

5 $w = -11$

7 $t = 45/13$

9 $t = 10/7$

11 $B = -2$

13 $l = A/w$

15 $a = 2(h - v_0 t)/t^2$

17 $v = (3w - 2u - z)/(u + w - z)$

19 $x = -a(b + 1)/(ad - c)$

21 $y' = 4/(y + 2x)$

23 $x = 4, y = 3$

25 $x = -55, y = 39$

27 $x = 1, y = a$

29 $x = 3, y = 6$

31 $A = (-4, 7)$

33 $A = (2, 9), B = (10, 1)$

35 $A = (-7, 8), B = (-3, 4)$

Section 2.1

S1 $5x - 15$

S3 $4m^2 - 38m + 90$

S5 $(3x + 3)/3$

S7 $x = \pm 3$

S9 $(18 \pm \sqrt{285})/3$

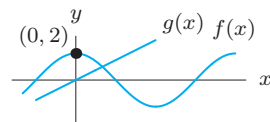1 (a) -4

  (b) ± 2

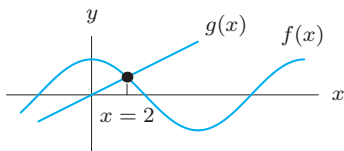3 (a) $-1/2$

  (b) -1

5 3/2

7 54

9 $(0, 2)$

11 Intersect at $x = 2$

13 100

15 $f(1/3) = 3.222$; $f(1)/f(3) = 0.238$; Not equal

17 (a) (i) $1/(1 - t)$
        (ii) $-1/t$
    (b) $x = 3/2$

19 (a) 48 feet for both
    (b) 4 sec, 64 ft

21 (a) $s(2) = 146$
    (b) Solve $v(t) = 65$
    (c) At 3 hours

23 (a) \$4261
    (b) $T(x) = 0.8x$
    (c) $L(x) = 0.0548x - 397$
    (d) \$4261

27 (a) $h(1) = b + c + 1$
    (b) $h(b + 1) = 2b^2 + 3b + c + 1$

29 $a/2$

31 $a/(a - a^2 + 1)$

33 (a) (i) 6
        (ii) 5
        (iii) Not defined
    (b) (i) $50 \le s \le 75$
        (ii) $76 \le s \le 125$

35 (a) 7000
    (b) 8500; 4 weeks after the beginning of the epidemic
    (c) $w = 1$, $w = 10$
    (d) $1.5 \le w \le 8$

Section 2.2

S1 $x = 3$

S3 $x < 15$

S5 $x > 8$

S7 $n < 0$

S9 $x > 5$ or $x < -5$.

1 $f(x) \le -(1/2)$ or $f(x) \ge (1/2)$

3 $-4 \le f(x) \le 5$

5 D: all real numbers $\ne -3$

7 D: all real numbers $\ne -3$

9 Domain: $x > 4$
   Range: $y > 0$

11 D: $x \ge 2$ or $x \le -2$

13 D: all real numbers

15 D: all real numbers
   R: all real numbers

17 $a = 3$

19 $a = -3$

21 D: $1 \le x \le 7$; R: $2 \le f(x) \le 18$

23 $y = 1/((x+5)\sqrt{-x})$

25 D: $0 \le t \le 12$
   R: $0 \le f(t) \le 200$

27 Domain: integers $0 \le n \le 200$
    Range: $0, 4, 8, \ldots, 800$

29 (a) 162 calories
    (c) (i) Calories = $0.025\times$ weight
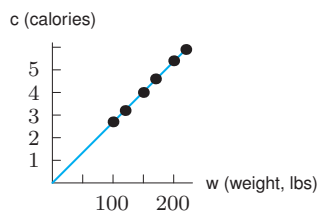
    (ii) (0,0) is the number of calories burned by a weightless runner
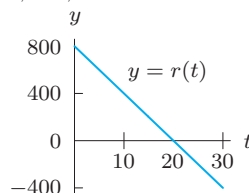   (iii) Domain $0 < w$; range $0 < c$
    (iv) 3.6

31 D: all real numbers;
    R: $h(x) \ge 6$

33 (a) $p(0) = 50$
         $p(10) \approx 131$
         $p(50) \approx 911$
    (c) $50 \le p(t) < 1000$

35 (a) 800; 200; -200
    (b)

    (c) $t = 20$; $t = 0$
    (d) Domain:$0 \le t \le 30$
         Range:$-400 \le r(t) \le 800$

Section 2.3

S1 $x > 0$

S3 $2 \le x \le 3$

S5 $x \le -1$ or $x \ge 2$

S7 Domain: $2 \le x < 6$
    Range: $3 \le x < 5$

S9 Domain: $-2 \le x \le 3$
    Range: $-2 \le x \le 3$

1

3

5 Domain: all reals;
   Range: $G(x) < 0$ and $G(x) \ge 3$

7 $y = \begin{cases} 5 - x & \text{for } x < 3 \\ -1 + (1/2)x & \text{for } x \ge 3 \end{cases}$

9 $y = \begin{cases} 4 - \frac{1}{2}x & \text{for } 1 \le x \le 3 \\ -9 + 2x & \text{for } 5 \le x \le 8 \end{cases}$
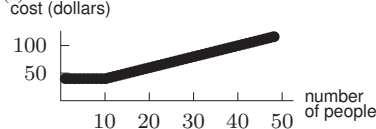
11 (a) Yes
    (b) No
    (c) $y = 1, 2, 3, 4$

13 (c) Domain: all $x, x \ne 0$
    Range: -1 and 1
    (d) False, $u(0)$ is undefined

15 (a)

    (b) Integers from 1 to 50
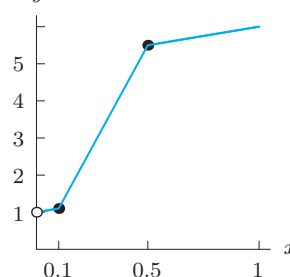   Even integers from 40 to 120

17 (a) \$1.01
    (b) $y = \begin{cases} 1 + x & \text{for } 0 < x < 0.1 \\ 10x + x & \text{for } 0.1 \le x \le 0.5 \\ 5 + x & \text{for } x > 0.5 \end{cases}$
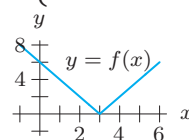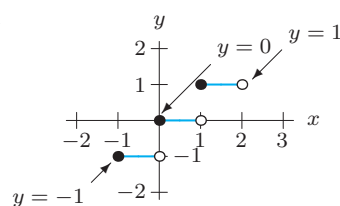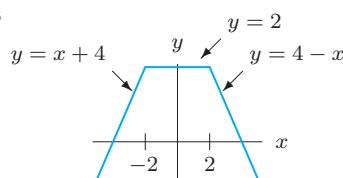   (c) \$4
    (d)

19 (b) 13-69

21 (a) $f(x) = \begin{cases} 2x - 6 & \text{for } x \ge 3 \\ 6 - 2x & \text{for } x < 3 \end{cases}$
    (b)

23 (a) $f(0) = 0$, $f(3) = 1$
    (b) Domain: $-1 \le x \le 5$;
         Range: $-3 \le f(x) \le 3$.

25 $y = \begin{cases} x^2 & \text{for } x < 0 \\ x - 1 & \text{for } x \ge 0 \end{cases}$

Section 2.4

S1 $y = (x + 4)/3$

S3 $y = (2x + 1)/(x - 2)$

S5 $y = \sqrt[3]{x + 4}$

S7 x

S9 $3y^2 - 12y + 5$

1 Area in sq cm at time t

3 Price for diameter d

5 0

7 -10

9 $9x - 4$

11 Year pop is P; years

13 Days for N inches snow; days

15 Diameter in inches of pizza costing c dollars

17 $f^{-1}(Q) = (Q - 3)^{1/3}$

19 $g^{-1}(y) = 1/(y - 1)$

21 (a) b
   (b) a
   (c) a
   (d) b

23 $n = f(100) = 0.4$ gal
   $A = f^{-1}(100) = 25{,}000$ ft^2

25 (a)   (i) 2
      (ii) 1
      (iii) 1
      (iv) 2
   (b) $f(0) = 2$ means $f^{-1}(2) = 0$
   (c) $f(1) = 0$ means $f^{-1}(0) = 1$

27 (a) 5000 loaves cost $653
   (b) 620 loaves $80
   (c) $790 for 6300 loaves
   (d) 1200 loaves for $150

29 (a) 12, perimeter for $s = 3$
   (b) 5; side for $P = 20$
   (c) $f^{-1}(P) = P/4$

31 $t = f^{-1}(H) = \frac{9}{5}H + 32 = t$

33 $20 + (50/9)2^{-n}$;
   $H = f(g(n))$ is temperature in $°$C at time n

35 (a) $A = f(r) = \pi r^2$
   (b) $f(0) = 0$
   (c) $f(r + 1) = \pi(r + 1)^2$
   (d) $f(r) + 1 = \pi r^2 + 1$
   (e) Centimeters

37 $f(t) = 4\pi(50 - 2.5t)^3/3$

39 $f(t) = \pi(2t - 0.1t^2)^2$

41 (a) 2 lbs cost $2.80
   (b) 0.5 lb costs $0.70
   (c) $0.35 buys 1/4 lb
   (d) $7 buys 5 lb

43 $23/4; -2$

45 $f^{-1}(y) = (y - 1)^{1/3}$

47 D: all real numbers
   R: all real numbers

49 D: all real numbers < 3
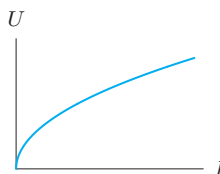   R: all real numbers > 0

Section 2.5

1 Concave down

3 Concave up

5 Concave up

7 Concave up

9 Rates of change: 2.889, 1.417, 1.167; Concave down

11 Possible graph:
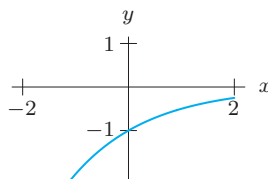
13 Increasing;
   concave up

15 Increasing;
   concave up then down

17 Increasing;
   concave up then down

19 (a) E, III
   (b) G, I
   (c) F, II

21 No

23 (a) Larger swims twice as fast
   (b) Increasing, concave down

   (c) $\sqrt{l}$ increasing
   (d) $\sqrt{l}$ concave down;
      greater

Chapter 2 Review

1 $f(-7) = -9/2$

3 $-3/31; 1$

5 32; $\sqrt[3]{9/4}$

7 (a) 1
   (b) $-1/2$

9 -8

11 (a) $2, 0, -2$
   (b) $x = -1$

13 Domain: $x \geq 3$ or $x \leq -3$
   Range: $q(x) \geq 0$

15 Domain: all real numbers
   Range: all real numbers

17 D: all real numbers
   R: all real numbers

21 (a) $2(1 - x)$
   (b) $2 - x$
   (c) x
   (d) $(1 - x)^2$
   (e) 0

   (f) $\sqrt{1 - x}$

23 $(3x - 7)^3 + 1$

25 Period in sec at time t

27 26

29 7

31 $2x^2 + 5$

33 $4x + 9$

35 Interest rate for $\$I$ interest; %/year

37 D: all real numbers $\geq b$;
   R: all real numbers ≥ 6

39 $f^{-1}(P) = (P + 2)/14$.

41 Time, yrs, at which pop is P mil

43 Rates of change: 4.35, 4.10, 3.80; Concave down

45 8; 81

47
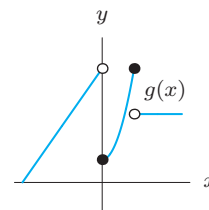
49 (a) -22
   (b) $3 - a^2$
   (c) $-a^2 + 10a - 22$
   (d) $-a^2 - 2$
   (e) $-a^2 + 25$

51 (a) $t = 6$
   (b) $t = 1, t = 2$

53 (a) -1
   (b) $x = \pm 3$
   (c) 0
   (d) -1
   (e) $3, -3$

55 $g^{-1}(7) = 1, g^{-1}(12) = 2, g^{-1}(13) = 3,$
   $g^{-1}(19) = 4, g^{-1}(22) = 5$

57 (a) $s = f(A) = +\sqrt{\frac{A}{6}}$
   (b) $V = g(f(A)) = \left(\sqrt{A/6}\right)^3$.

59 (a) $C(3.5) = \$6.25$
   (b) $C^{-1}(\$3.5) \approx 1.67$

61 (a) $d/\sqrt{2}$
   (b) s^2
   (c) $d^2/2$
   (d) $h(d) = g(f(d))$

63 (a) $(-2, 2)$
   (b) $(-2\sqrt{2}, -2), (2\sqrt{2}, -2)$
   (c)
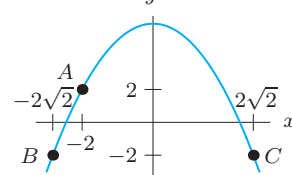
   (d) -3

65 (a) $t(400) = 272$
   (d) $t(2x) = t(x)/2$

69 $y = \sqrt{x-4} + 1/(x-8)$

71 (a) Increasing until year 60, then decreasing
   (c) Appears concave up
   (d) Greatest between 40 and 60;
       smallest between 60 and 70
   (f) 1840; potato famine

Ch. 2 Understanding

1 False

3 False

5 False

7 False

9 True

11 True

13 False

15 False

17 True

19 True

21 True

23 False

25 True

27 True

29 True

31 True

33 False

35 True

37 True

39 True

41 True

Section 3.1

S1 $-200t$

S3 $u(u-2)$

S5 $(3x-4)(x+1)$

S7 $(4x-1)(4x+1)$

S9 $x = -6$ or $x = -1$

1 Yes; $f(x) = 2x^2 - 28x + 99$

3 Yes; $g(m) = -2m^2 + \sqrt{3}m + 42$

5 Not quadratic

7 Yes; $T(n) = (\sqrt{3} - 1/2)n^2 + \sqrt{5}$

9 $x \approx -0.541$ and $x \approx 5.541$

11 $x = 2, 3/2$

13 $x = 2, x = -1$

15 $x = (-1 \pm \sqrt{6})/5$

17 No zeros

19 $y = (7/4)(x-1)(x-4)$

21 3 sec

23 $f(x) = a(x-1)(x-2)$ for any constant a
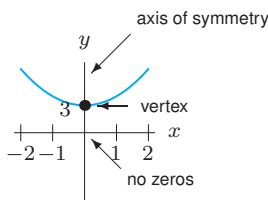
25 For example $y = (x+2)(x-3)$
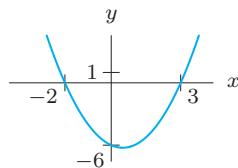
27
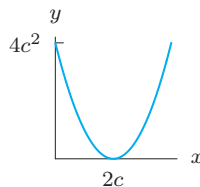
29 $y = -(5/12)x^2 - (5/3)x + 5$

31 $k = -30, r = 8, s = 0.2$

33 (a) 4 meters per second
   (b) 2 seconds
   (c) Concave up

35 -2.4% in 2004

37 (a) 5 km
   (b) 4430 m
   (c) $h \approx -0.000000255d^2 + 5$

Section 3.2

S1 $(y-6)^2 - 36$

S3 $(c+3/2)^2 - 37/4$

S5 $r = 4, 2$

S7 $q = 1/5 \pm \sqrt{41}/5$

S9 $n = -5, 1$

1 $(1, 2)$; $x = 1$; opens upward

3 Vertex: $(-11/2, -137/4)$
   Axis of symmetry: $t = -11/2$

5 (a) $a = 1, b = 0, c = 3$
   Axis of symmetry: y-axis
   Vertex: $(0, 3)$
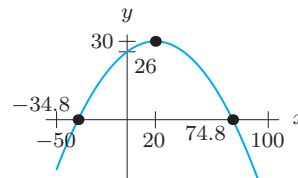   No zeros
   y-intercept: $y = 3$

   (b) $a = -2, b = 4, c = 16$
   Axis of symmetry: $x = 1$
   Vertex: $(1, 18)$
   Zeros: $x = -2, 4$
   y-intercept: $y = 16$
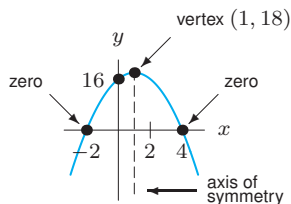
7 $k = 4$

9 $y = -(3/16)(x-4)^2 + 7$

11 $y = \frac{7}{9}(x-3)^2 - 5$

13 $f(x) = (x+4)^2 - 13$;
   Vertex: $(-4, -13)$; axis: $x = -4$

15 $p(t) = 2(t - 0.03)^2 + 0.0982$, vertex
   $(0.03, 0.0982)$, axis of symmetry $t = 0.03$

17 $(1/2)x^2 - (1/2)x - 6$;
   $(1/2)(x - 1/2)^2 - (49/8)$;
   $(1/2)(x-4)(x+3)$

19 $2s^2 - 7s - 15$;
   $2(s - 7/4)^2 - (169/8)$;
   $2(s-5)(s+3/2)$

21 $y = (1/4)(x-4)^2 + 2$

23 $y = (-2/49)(x-4)^2 + 2$

25 (a)
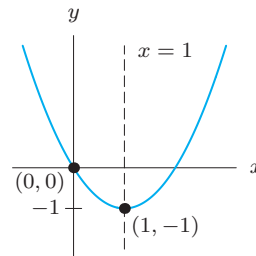
   (b) $y = (x-1)^2 - 1$ or $y = x^2 - 2x$
   (c) Range: $y \geq -1$
   (d) The other zero is $(2, 0)$

27 Vertex: $(20, 30)$

29 12.5 cm by 12.5 cm; $k/4$ by $k/4$

31 (b) Maximum height: $t = T/2$

Chapter 3 Review

1 $f(x) = -2x^2 + 13x - 15$; $a = -2, b = 13, c = -15$

3 $w(n) = 3n^2 + 6n + 0$; $a = 3, b = 6, c = 0$

5 $x = -1/3$

7 No zeros

9 2 and 5

11 There are no real zeros

13 $y = -3(x-1)^2 - 2$

15 $(1/4)(x-7)^2 + 3$

17 $y = 4(x+1)(x-2)$

19 $y = (x+1)(x-3)$

21 $y = -(x-2)^2$

23 Vertex is $(3/4, -2/3)$, axis of symmetry is $x = 3/4$, y-intercept $y = 11/24$, concave up

25 Vertex is $(0.6, 0)$, axis of symmetry is $x = 0.6$, y-intercept is $y = 0.36$, concave up

27 $y = 0.3(x-6)(x+4)$, zeros at $x = 6$ and $x = -4$, vertex at $(1, -7.5)$

29 $y = -3(x-6)(x-2)$, vertex is $(4, 12)$, zeros at $x = 6$ and $x = 2$

31 Rates of change: $-4, 0, 4$; Concave up

33 1/2 second

Ch. 3 Understanding

1 True

3 False

5 False

7 False

9 False

11 True

13 False

15 True

Ch. 3 Skills: Factoring

1 $6x - 14$

3 $12x + 12y$

5 $2x^2 + 5x$

7 $-50r^2 - 60r^2 s$

9 $5xz - 10z - 3x + 6$

11 $x^2 + 4x - 12$

13 $yz + 3y + z + 3$

15 $5xz - 10z - 3x + 6$

17 $x - 25$

19 $Pp^2 - 6Ppq + 9Pq^2$

21 $-2x - 2\sqrt{2x} - 1$

23 $2(x+3)$

25 $5(z-6)$

27 $5(2w-5)$

29 $3u^2(u^5 + 4)$

31 $7rs(2r^3 s - 3t)$

33 $(x-2)(x-1)$

35 Cannot be factored

37 Cannot be factored

39 $(2x+1)(x+2)$

41 $(x+7)(x-4)$

43 $x(x+3)(x-1)$

45 $(x+2y)(x+3z)$

47 $(ax-b)(ax+b)$

49 $(B-6)(B-4)$

51 Cannot be factored.

53 $(t-1)(t+7)$

55 $(a-2)(a^2+3)$

57 $(d+5)(d-5)(c+3)(c-3)$

59 $(r+2)(r-s)$

61 $xe^{-3x}(x+2)$

63 $P(1+r)^3$

65 $(k+2m)(d-3e)$

67 $(2g-3h)(4s+5m)$

69 $x = (-3 \pm \sqrt{249})/8$

71 $x = 7/4$

73 $t = 3 \pm \sqrt{6}$

75 $x = 2, x = -4/3$

77 $N = 3, N = 1$

79 $x = 1 \pm \sqrt{2}$

81 $t = 3 \pm \sqrt{6}$

83 $a = -10, \pm 2\sqrt{5}/5$

85 $z = -7/2$

87 $L = \pm 1/2$

89 $r = \pm 5$

91 $x = 0, x = 36$

93 $x = -4/3, x = 2$

95 $b = \sqrt[5]{C/A}$

97 $x = 4m$

99 $x = 1/2$ and $y = 2$, or $x = -1/2$ and $y = -2$

101 $x = -3$ and $y = -5$, or $x = 1$ and $y = 3$

103 $(0, 0)$ and $(3, 9)$
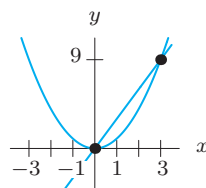
105 $(-5, 25), (3, 9)$

Ch. 3: Completing Square

1 $(x+4)^2 - 16$

3 $2(r+5)^2 - 50$

5 $(a-1)^2 - 5$

7 $3(r+3/2)^2 - 43/4$

9 $(x-1)^2 - 4$

11 $-(x-3)^2 + 7$

13 $(-3, -6)$

15 $(-4, 18)$

17 $(1/2, -23/4)$

19 $(1, -2)$

21 $(7/4, -25/8)$

23 $g = 6, -4$

25 $d = 2, -1$

27 $s = -5/2 \pm \sqrt{27}/2$

29 $p = -9/10 \pm \sqrt{101}/10$

31 $y = -1/2, -2$

33 $w = (-1 \pm \sqrt{17})/2$

35 $q = (-3 \pm \sqrt{15})/2$

37 $s = \left(-3 \pm \sqrt{13}\right)/2$

39 $u = (3 \pm \sqrt{5})/5$

41 $y = 1 \pm \sqrt{7}$

43 $w = 3, 2, -2$

45 $m = (-5 \pm \sqrt{3})/7$

Section 4.1

S1 0.06

S3 0.12%

1 Yes; $g(w) = 2(1/2)^w$

3 Yes; $f(x) = (1/4)9^x$

5 Yes; $q(r) = -4(1/3)^r$

7 Yes; $Q(t) = 2^t$

9 Not exponential

11 1.28 (per decade)

13 0.20 (per century)

15 $a = 34.3; b = 0.788; r = -21.2\%$

17 $a = 0.0022; b = 0.0811; r = -91.89\%$

19 $109,272.70

21 (a) (ii)
    (b) (i)
    (c) (iv)
    (d) (ii)
    (e) (iii)
    (f) (i)

23 (a) $Q = 35(0.92)^t$
    (b) 15.204

25 (a) $Q = 5.35(1.008)^t$
    (b) 5.794

27 (a) $Q = 0.2(0.995)^t$
    (b) 0.190

29 $P = 70(1.019)^t$

31 $f(n) = P_0(0.8)^n$
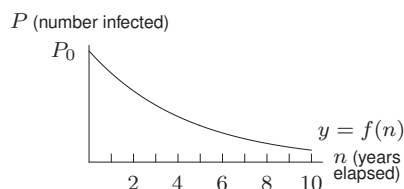
33 (a) $P = 7.50(1.035)^t$
    (b) $\approx$ $14.92

35 (a) $C = 100(0.84)^t$
    (b) 41.821 mg

37 (a) 14.026 m; 19.371 m
    (b) 2030-55 larger; graph concave up

39 (a) $P = 1.15(1.0135)^t$
    (b) 1.230 billion; 1.315 billion
    (c) 15.525 million people per year
    (d) About 29 people per minute

41 (a) 31,532 megawatts; 62.3 megawatts
    (b) 8.1%; 0.2%

43 $5 \cdot 4^{-\frac{1}{6} \cdot t}$; $a = 5, k = -1/6$

45 (a) $N = 13.4(1.05)^t$
    (b) 17.957 million; 11.024 million

47 (a) $N(r) = 64(1/2)^r$
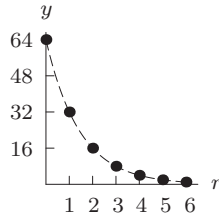
(b) 6

49 9.712%

51 (a) $444 per month
  (b) $286.20 per month
  (c) $506.40 per month
  (d) $11,232
  (e) $23,112

53 366.875 miles

55 0.5

57 b_0

59 t_0 decreases

61 (a) $R = Nr$
  (b) $A = R/P = Nr/P$
  (c) $N_{\text{new}} = 1.02N$
    $r_{\text{new}} = 1.03r$
  (d) $R_{\text{new}} = 1.0506R$; 5.06%
  (e) $A_{\text{new}} = (0.9728)A$; average revenue falls
    by 2.7%

Section 4.2

S1 b^{10}

S3 $6a^7b^{10}$

S5 5.6; 6.354

S7 $x = 1.710$

S9 $x = 1.393$

1 (a) $p = 2.50 + 0.03t$
  (b) $p = 2.50 - 0.07t$
  (c) $p = 2.50(1.02)^t$
  (d) $p = 2.50(0.96)^t$

3 B, C, D exponential

5 $Q = 70.711(0.966)^t$

7 $f(x) = 2(1/3)^x$

9 $Q = 0.7746 \cdot (0.3873)^t$

11 $y = 50(0.833)^x$

13 $y = 2(3/2)^x$

15 $y = 160(0.983)^x$

17 Not exponential

19 $g(t) = 5.7(0.315)^t$

21 f is exponential, h is linear, g is neither

23 (a) $g(x)$ is linear
  (b) $g(x) = 2x$
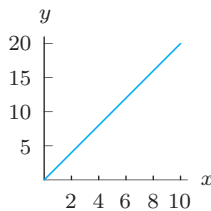
25 (a) $i(x)$ is linear
  (b) $i(x) = 18 - 4x$
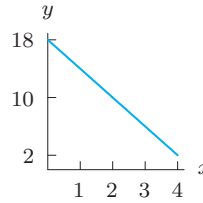
27 $x < -1.69$ and $x > 2$

29 $p = 20(1.0718)^x$; $q = 160(0.8706)^x$

31 Exponential,
  $R(t) = 2.001(1.030)^t$

33 (a) $P = 1154.160(1.20112)^t$
  (b) $1154.16
  (c) 20.112%

35 $P = 1046(0.798)^t$; decreasing by 20.2%/yr

37 (a) $W = 43.45 - 0.126t$; 40.43 seconds
  (b) $W = 43.45(0.997057)^t$; 40.48 seconds

39 (a) $P = 3500 - 180t$; -180 fish/year
  (b) $P = 3500(0.93)^t$; -7%/year
  (c)
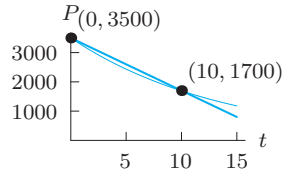
41 (a) Linear
  (b) $L = 0.25t + 75.85$
  (c) 88.35 years

43 (a) $N = 84 + 11.3684t$;
    increasing by 11.3684 million people per
    year
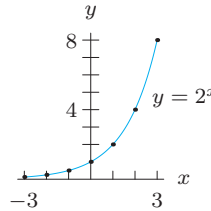 (b) $N = 84(1.0693)^t$;
    increasing by 6.93% per year
  (c) Linear: 425.0520 million; Exponential:
    626.9982 million

45 (a) Neither
  (b) Not possible

Section 4.3

1 (b)

3 $h(x)$ top; $g(x)$ middle; $f(x)$ bottom

5 Yes

7 No

9 No

11 D

13 D

15 (a) 13 ft^3
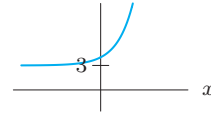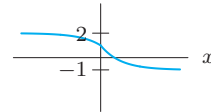 (b) 3.2 weeks

17 $q = 5.662$

19 $t = 2.452$

21 Zero

23

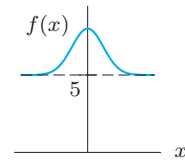25

27

29 (a) $-\infty$
  (b) $-\infty$

31 (a) All
  (b) b
  (c) b, a, c, p
  (d) $a = c$
  (e) d and q

33 Increasing: $b > 1$, $a > 0$ or $0 < b < 1$,
  $a < 0$;
  Decreasing: $0 < b < 1$, $a > 0$ or $b > 1$,
  $a < 0$;
  Concave up: $a > 0$, $0 < b < 0$ or $b > 1$.
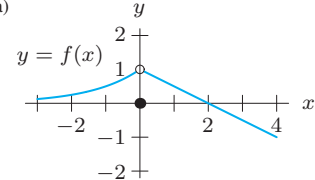
35 y_0 decreases, $y_0 > b$

37 (a) $P = 651(0.9925)^t$
  (b) 603,790
  (c) $t = 22.39$

41 (a) $P \approx 0.538$ millibars
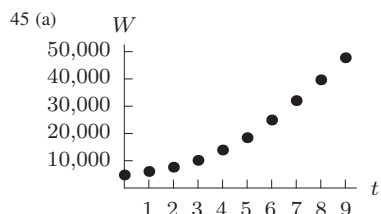 (b) $h \approx 0.784$ km

43 (a)

  (b) $f(x) < 1$
  (c) $(0, 0)$ $(2, 0)$
  (d) As $x \to +\infty$, $f(x) \to -\infty$
    As $x \to -\infty$, $f(x) \to 0$
  (e) Increasing for $x < 0$, decreasing for $x > 0$

45 (a)

(b) $W = 4710(1.306)^t$; answers may vary
(c) 30.6%/yr

Section 4.4

1 (a) 8.300%
  (b) 8.322%
  (c) 8.328%

3 165.3%

5 (a) \$1270.24
  (b) \$1271.01
  (c) \$1271.22

7 (a) \$505
  (b) \$505.02
  (c) \$505.03

9 (a) \$525
  (b) \$525.62
  (c) \$525.64

11 (a) Nom: 1% Eff: 1%
  (b) Nom: 1% Eff: 1.004%
  (c) Nom: 1% Eff: 1.005%

13 (a) Nom: 3% Eff: 3%
  (b) Nom: 3% Eff: 3.034%
  (c) Nom: 3% Eff: 3.045%

15 34.392%

17 7.352%

19 1.628%

21 (i) (b)
  (ii) (a)
  (iii) (c)
  (iv) (b), (c) and (d)
  (v) (a) and (e)

Section 4.5

S1 1.073

S3 1.433

S5 2.3; 7.636

S7 161.6; 202.027

S9 $f(t) = 27e^{0.12t}$

S11 $Q = 1{,}096.633e^{-3t}$

S13 $m(x) = \frac{7}{\sqrt 3}e^{-0.3x}$

S15 $H(r) = \frac{1}{6}e^{0.65r}$

1 Bottom to top:
  $y = e^x, y = 2e^x, y = 3e^x$

3 (a)=(II); (b)=(III); (c)=(IV); (d)=(I)

5 $f(x) = e^{-x}$
  $g(x) = e^x$
  $h(x) = -e^x$

7 (a)=(I); (b)=(II); (c)=(III); (d)=(IV)

9 0

---

11 2

13 $a > 0, k > 0$

15 (a) $Q_0 = 2.7$
  (b) Decreasing
  (c) −88%
  (d) Not continuous

17 (a) $Q_0 = 0.01$
  (b) Decreasing
  (c) −20%
  (d) Continuous

19 (a) $Q_0 = 1$
  (b) Increasing
  (c) 100%
  (d) Not continuous

21 (a) $Q = 8(1.12)^t$; 24.847
  (b) $Q = 8e^{0.12t}$; 26.561

23 (a)   (i) 23.183
    (ii) 23.645
  (b) Continuous growth faster

25 (a) $P = 3000 + 200t$
  (b) $P = 3000(1.06)^t$
  (c) $P = 3000e^{0.06t}$
  (d) $P = 3000 - 50t$
  (e) $P = 3000(0.96)^t$
  (f) $P = 3000e^{-0.04t}$

27 (a) $P(t) = 22{,}000e^{0.071t}$
  (b) $\approx 7.358\%$

31 54.931 years

33 (a) \$24,102.64
  (b) 124.323 years

35 Eff. yield: 20.925%
  Cont. rate: 19%

37 5.127%

39 (a)   (i) 6.14%
    (ii) 6.17%
    (iii) 6.18%
    (iv) 6.18%
  (b) 1.0618
    The highest possible APR is 6.18%.

41 From best to worst: B, C, A

43 (a) $G = 145.8e^{0.051t}$
  (b) 5.23%
  (c) $G = 145.8(1.0523)^t$
  (d) The two formulas have the same graph

45 \$143.70

47 $a = b > 1$
  $0 < k < 1$
  $l < 0$

49 (a) $A = 50e^{-0.14t}$
  (b) 12.330 mg
  (c) 2025

51 \$27,399.14

53 (a) 2.708333333
  (b) 2.718055556
  (c) 2.718281828; thus (a) is correct to 2 correct
   digits, while (b) is correct to 4 digits
  (d) 13 terms

Chapter 4 Review

1 550

3 495

5 411.8

---

7 $P = 2200(0.968)^t$

9 20%; 2%.

11 Linear: $p(r) = 10 + 3r$

13 Neither

15

Yr	2010	2011	2012	2013	2014
\$	95	101.65	108.77	116.38	124.53

17 (a) 4.2%
  (b) $\approx 4.28\%$
  (c) $\approx 4.29\%$

19 $h(x) = 3(5)^x$

21 $g(x) = 2(4)^x$

23 $g(x) = 14.20(0.6024)^x$

25 (a) $f(x) = \frac{31}{8}x + \frac{49}{4}$
  (b) $f(x) = 5(2)^x$

27 $y = (1/2)^x$

29 $y = \frac{1}{5}(3)^x$

31 $y = 2(0.8)^x$

33 (a) $P(t) = 2.58 + 0.09t$,
    increases by 90,000 people per year
  (b) $P(t) = 2.68(1.026)^t$,
    increases by 2.6% per year

35 0

37 15

39 $-\infty$

41 $N = 10(1.13)^t$; 13%/yr

43 (a) $S = 128.4(1.13)^t$
  (b) Increasing by 13%/yr
  (c) No

45

47
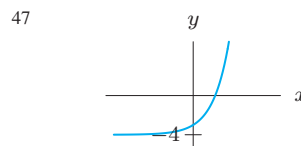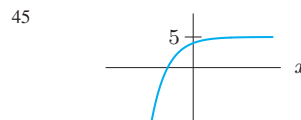
49 f

51 $y = 2$

55 (a) Initial balance = \$1100
    Effective yield = 5%
  (b) Initial balance = \$1500
    Effective yield $\approx$ 5.13%

57 $p(x) = 7e^x \sqrt{e}/20$

59 $s(w) = (v - 4t + kv)j^w$
  $a = v - 4t + kv, b = j$

61 $g(n) = 1000(0.7071)^n$

65 $d > b$

67 f matches (ii) and (iv); g matches (i) and (iii)

69 (a)
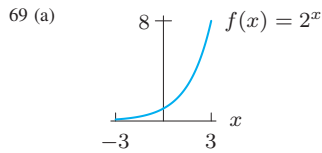
(b) 0.69
(c) 1.10
(d) $e \approx 2.72$
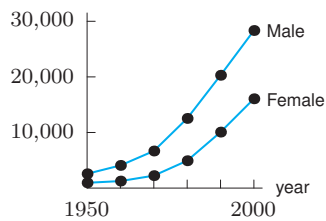
71 $V = 12{,}000e^{0.042t}$

73 $y = -13.1x + 2090$

75 $a = 12{,}000;\ k = -12.2\%;\ b = 0.8851;$
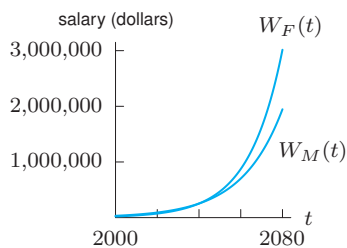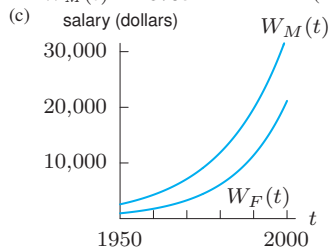$r = -11.49\%$

77 (a) $15.269(1.122)^t$
(b) 108,066
(c) Not useful

79 t_0 decreases

81 (a) salary (dollars)

(b) $W_F(t) = 953e^{0.062(t-1950)}$ (women)
$W_M(t) = 2570e^{0.051(t-1950)}$ (men)
(c) salary (dollars)

(d) Yes, in about 2060
(e) Not reliable

83 50.7%

Ch. 4 Understanding

1 True

3 True

5 False
7 True
9 True
11 False
13 False
15 True
17 True
19 False
21 True
23 False
25 True
27 False
29 True
31 False

Ch. 4 Tools: Exponents

1 25
3 10,000
5 5
7 1
9 4
11 4
13 16
15 -121
17 2100
19 2
21 32
23 100,000
25 -6
27 4
29 $1/(3\sqrt{3})$
31 $1/625$
33 0.5
35 y^4
37 $x^{5/2}y^2$
39 $5x^{3/2}z^2$
41 $r^{3/2}$
43 $8s^{7/2}$
45 $4\sqrt{3}u^5v^6y^{5/2}$
47 $16S^2xt^2$
49 $A^3/\left(3B^3\right)$
51 $(M+2)^2$
53 $3a$
55 $25(2b+1)^{20}$
57 -8
59 Not a real number
61 $1/512$
63 Not a real number
65 $x = \pm 1.690$
67 $(2.5, 31.25)$
69 False
71 True
73 True

75 $x = r + s$
77 $x = 5/a$
79 $x = 3/a$
81 $x = b/a$

Section 5.1

S1 $x = 6$
S3 $z = 3/2$
S5 No solution
S7 $t = 14/9$
S9 $t = -1/8$

1 $19 = 10^{1.279}$
3 $26 = e^{3.258}$
5 $P = 10^t$
7 $8 = \log 100{,}000{,}000$
9 $v = \log \alpha$
11 (a) 3
(b) 1.5
(c) 0
(d) $1/2$
(e) 5
(f) 2
(g) $-1/2$
(h) 100
(i) 1
(j) 0.01
13 $(\log 11)/(\log 2) = 3.459$
15 $(\ln 100)/(0.12) = 38.376$
17 $(\log(48/17))/(\log(2.3)) = 1.246$
19 (a) $2x$
(b) x^3
(c) $-3x$
21 (a) 3, 3
(b) 5, 5
(c) $-1, -1$
(d) $-1, -1$
(e) 2, 2
(f) 3, 3
Both answers equal
23 (a) True
(b) False
(c) False
(d) True
(e) True
(f) False
25 $x = 57.002$
27 $x = (a - \log M)/(\log N)$
29 $x = 2.714$
31 (a) 10; 15%
(b) $t \approx 10.5$
(c) $t = (\ln 0.2)/(-0.15) = 10.730$
33 (a) $\log 15 - \log 5$
(b) $2 \log 5$
(c) $\log 15 + \log 5$
35 $(\log(91/46))/(\log(1.1))$
37 $(\ln 6/0.044)$
39 $x = \ln 10 - 4$
41 $\log(35/2)/\log(2/27)$
43 $t = \ln(500/400)/0.02$
45 $\ln 10 - 4$

47 $(\ln Q - \ln P)/k$

49 $x = -2, \dfrac{1}{3},$ or $-\dfrac{1}{3}$

51 $-2, 1/3, -1/3$

53 The log increases by 0.3010

55 $\log \sqrt{vw} = (\log v + \log w)/2$

57 $B > A$

Section 5.2

S1 $(5x)^{-1}$

S3 $t^2/2$

S5 $x = (\log 9)/(\log 4) = 1.585$

S7 $x = \ln(13/2) = 1.872$

S9 $x = 93/2$

1 $y = 25(1.0544)^t$, 5.44%/yr, 5.3%/yr

3 $y = 6000e^{-0.1625t}$, $-15\%/yr, -16.25\%/yr$

5 $Q = 4 \cdot 1096.633^t$

7 $Q = (14/5)1.030^t$

9 $Q = 12e^{-0.105t}$

11 $Q = 14e^{-0.208t}$

13 $a = 230, r = 18.2\%, k = 16.72\%$

15 $a = 0.81, r = 100\%,$ and $k = 69.31\%$

17 $a = 12.1, r = -22.38\%, k = -25.32\%$

19 $a = 5.4366, b = 0.4724, r = -52.76\%, k = -3/4$

21 $t \approx 3.466$

23 About 26 years

25 About 12.3 years

27 6.301 minutes

29 (a) 7.70%
   (b) 6.18%

31 27.756 years

33 (a) 4.729%
   (b) 4.621%

35 -34.7% per hour

37 23.1%/yr; $W = 90e^{0.231t}$

39 (a) 10; 30; and 70 yrs
   (b) 14.207; 28.413; and 42.620 yrs

41 (a) 4 hours
   (b) -17.3% per hour; $Q = 150e^{-0.173t}$

45 (a) 300; 600
   (b) 34.739 years

47 (a) 27.465 years
   (b) 28.011 years

49 (a) $R(t) \approx 200(0.8909)^t$
   (b) ≈ 4.422 hours
   (c) concave up

51 5092.013 years ago

53 (a) $f(x) = \frac{1}{2}(4)^x$
       $g(x) = 4\left(\frac{1}{3}\right)^x$
       $h(x) = x + 2$
   (b) $x = \log 8/\log 12$
   (c) $x = 1.378$ or $x = -1.967$

57 (a) $20, 395, 954$
   (b) 5.615 years, 7.2 years

(c) 1000 toads

59 $t = -10 \ln(-2 \ln 0.5) = -3.266$

61 (a) $v = \log 1.12, w = \log 6.3$
   (b) $t = w/v; t = 16.241$

Section 5.3

S1 -4

S3 $\log 100{,}000 = 5$

S5 $x = e^{-12}$

S7 $\ln x + 3\ln(7 - x)$

S9 $\ln x^5$

1 $y = 0, y = 0, x = 0$

3 A: $y = 10^x$, B: $y = e^x$
   C: $y = \ln x$, D: $y = \log x$

5

(a)

7
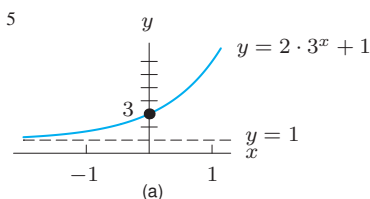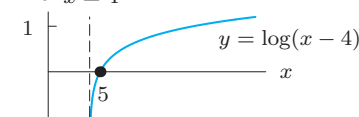
(c)

9 Vertical asymptote at 3, Domain $(3, \infty)$
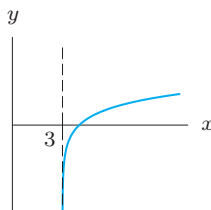
11 (a) 0
   (b) $-\infty$

13 (a) $-\infty$
   (b) $-\infty$

15 0.1 moles/l

17 3.162×10^{-5} moles/l

21 (a) $t(x)$
   (b) $r(x)$
   (c) $s(x)$

23 100 watts/cm^2

25 37

27 79,432,823

29 $M_2 - M_1 = \log(W_2/W_1)$

31 (a) $10^{-2}, 10^{-4}, 10^{-7}$

(b) Less

33 (a) 0.005 moles/liter
   (b) 3.3×10^{-4} moles H$^+$ ions
       1.987×10^{20} ions

35 $y = b^x, 0 < b < 1$

37 $y = \ln x$

39 $y = -b^x, b > 1$

Section 5.4

S1 1.455×10^6

S3 6.47×10^4

S5 3.6×10^{-4}

S7 $10^4 < \log 12{,}500 < 10^5$

S9 $10^{-1} < 1/3 < 10^0$

1 Log

3 Linear

7 (a) $y = -3582.145 + 236.314x$; $r \approx 0.7946$
   (b) $y = 4.797(1.221)^x$; $r \approx 0.9998$
   (c) Exponential is better fit

9 $10^{-3.65}$ million years ago

11 A: $1.58
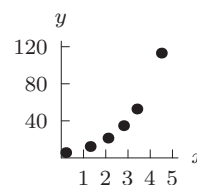   B: $6.31
    C: $31.62
    D: $630.96
    E: $10,000.00
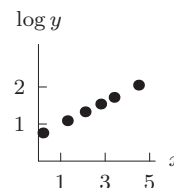   F: $125,892.54
    G: $6,309,573.45
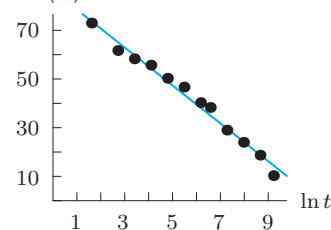   Answers are approximate.

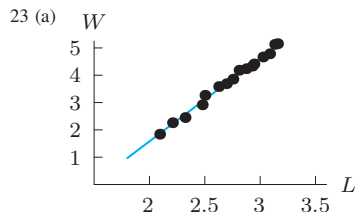17 (a)

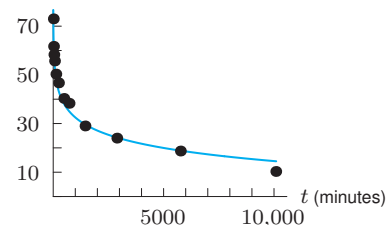(b) Exponential
(c) Linear

19 Yes

21 (a) $a \approx -7.787, b \approx 86.283$
   (b)

(c) $69,918.342$ minutes ≈ 45 days

0.172 minutes ≈ 10 seconds

(d)

23 (a)

(b) $W = 3.06L - 4.54$
(c) $w = 0.011\ell^{3.06}$

Chapter 5 Review

1 $Q = 7(0.0000454)^t$

3 $Q = 4e^{1.946t}$

5 $Q = 4e^{2.703t}$

7 $(\log 3)/(\log 1.04)$

9 $(\log(14/3))/(\log 1.081)$

11 $(\log(12/5))/(3\log 1.014)$

13 $(\log 1.6)/(\log 1.031)$

15 47

17 2.324

19 $(1/0.049) \cdot \ln(25/13) \approx 13.345$

21 $x = 1000$

23 $2(x+1)$

25 $\ln(AB)$

27 Domain: $x > 20$; Asymptote: $x = 20$

29 Domain: $x < 300$; Asymptote: $x = 300$

31 Domain: $x > -15$; Asymptote: $x = -15$

33 3.7

35 2.2

37 0.6

39 (a) $q + 4p$
(b) $-q$
(c) p/q
(d) $3q$

41 (a) $\ln 8 - 3 \approx -0.9206$
(b) $\log 1.25 / \log 1.12 \approx 1.9690$
(c) $-\dfrac{\ln 4}{0.13} \approx -10.6638$
(d) 105
(e) $\frac{1}{3}e^{3/2} \approx 1.4939$
(f) $e^{1/2}/(e^{1/2} - 1) \approx 2.5415$
(g) -1.599 or 2.534
(h) 2.478 or 3
(i) 0.653

43 158.5 times larger

45 15.85 times larger

47 (a) Initial balance: $1100
Effective yield: 5%
(b) Initial balance: $1500
Effective rate: 5.127%/yr
(c) Continuous rate: 4.879%/yr

49 (a) 1412 bacteria
(b) 10.011 hours
(c) 1.005 hours

51 (a) 7 years
(b) 10.4%

53 $\ln(1.5)/0.2 = 2.027$

55 $t = (\ln 2)/0.22$

57 (a) Domain: all x
Range: $y > 0$
Asymptote: $y = 0$
(b) Domain: all $x > 0$
Range: all y
Asymptote: $x = 0$

59 (a) Log function

(b)
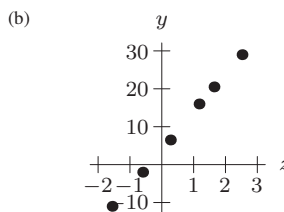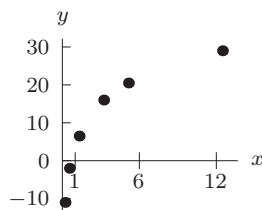
(c) Linear; $y = 4 + 9.9z$
(d) $y = 4 + 9.9\ln x$
(e) $x = 0.67e^{0.1y}$;
Exponential function of y

61 (a) $Q(t) = 2e^{-0.04t}$
(b) 3.921%
(c) After 51.986 hours
(d) 54.931 hrs after second injection

63 (a) $\approx 33.517\%$
(b) $k \approx 4.082\%$, continuous hourly decay rate

65 (a) 10
(b) 50
(c) 10^{50}

67 $\sqrt[8]{k}$

Ch. 5: Understanding

1 False

3 True

5 True

7 True

9 True

11 False

13 False

15 False

17 True

19 False

21 False

23 True

25 True

27 True

29 True

31 True

33 False

35 False

37 False

Ch. 5 Skills: Logs

1 0

3 8

5 0

7 2

9 $\log 0.0001 = -4$

11 $\ln 0.135 = -2$

13 $10^{-2} = 0.01$

15 $e^{x^2} = 4$

17 Cannot be rewritten

19 $\log(x^2 + 1) - 3\log x$

21 Cannot be rewritten

23 Cannot be rewritten

25 $\log 12x$

27 $\log(\sqrt{x}y^4)$

29 $\log\left((x+1)^3(x+4)^2\right)$

31 $\log(9 - x^2)$

33 Cannot be simplified

35 0

37 $4z$

39 $-\ln(e^x + 1)$

41 $x = (\log 3)/(\log 5) \approx 0.683$

43 $x = -(\ln 9)/5 \approx -0.439$

45 $x = (\log 77)/(6\log 19 - 4\log 7) \approx 0.440$

47 $x = (10^{3/2} - 17)/9 \approx 1.625$

49 $x = (e + 1)/6 \approx 0.620$

Section 6.1

S1 2

S3 -1

S5 $x = 0$

S7 $x = -8$

S9 (a) Shift right 4 units
(b) Shift down 7 units
(c) Shift left $\sqrt{2}$ units
(d) Shift right 3 units and up 5 units
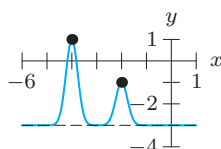
1 (a) $-3, 0, 2, 1, -1$
One unit right

(b) $-3, 0, 2, 1, -1$
One unit left
(c) $0, 3, 5, 4, 2$
Up three units
(d) $0, 3, 5, 4, 2$
One right and three up

3 (a) $(3, 1)$
(b) $(-2, -4)$
(c) $(6, -6)$

5
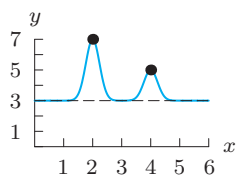
7

11 $-50 \le R(s) - 150 \le 50$

13 $(1/2)n^2 + 1$

15 $(1/2)n^2 - 3.7$

17 $(1/2)n^2 + \sqrt{13}$

19 $(1/2)n^2 + 3n + 23/2$

21 $3^w - 3$

23 $3^w + 1.8$

25 $3^{w+2.1} - 1.3$

27 (a) (i) 248
   (ii) 142
   (iii) 4
   (iv) 12
   (v) 378
   (vi) -18
   (vii) 248
   (viii) 570
   (ix) 13
(b) (i) $x = 2$
   (ii) $x = 8$
   (iii) $x = 7$
(c) $x = 1, 4$

29 $y = f(x - 2) - 6$

31 (a) $g(x) + 3$
(b) $g(x - 2)$

33 (a) Population 100 people larger than original
(b) Population same as 100 years earlier

35 Average for 7 mos, 10 mos
Above average

37 Up 1, right 3

39 Vertical shifts
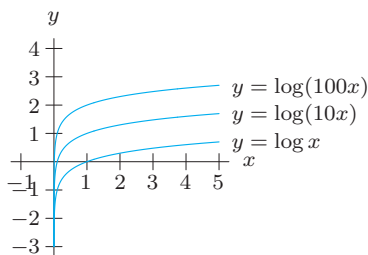
41 Shift $y = x^2$ right by 5 units to get $y = (x - 5)^2 = x^2 - 10x + 25$
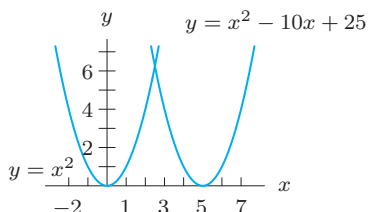
43 Shift up 3

45 Shift left 4

47 Shift left b, down a

49 (a) $T(d) = S(d) + 1$
(b) $P(d) = S(d - 1)$

51 $w(x) = v(x - 5) - 7; h = 5, k = -7$

53 (a) $t(x) = 20 + 7x$ for $x \ge 0$
(b) $n(x) = t(x) + 5$
(c) $p(x) = t(x - 2) + 10$ for $x \ge 2$

55 (a)
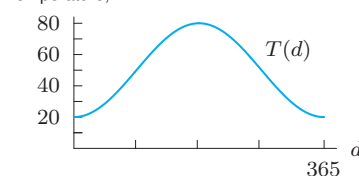
57 $H(t) - 37$

Section 6.2

S1 20.086

S3 0.050

S5 (a) $f(-x) = 2x^2$
(b) $-f(x) = -2x^2$

S7 (a) $f(-x) = -2x^3 - 3$
(b) $-f(x) = -2x^3 + 3$

S9 (a) $f(-x) = 3x^4 + 2x$
(b) $-f(x) = -3x^4 + 2x$

1 (a) $(-2, -3)$
(b) $(2, 3)$

3 -7

5 Domain: $t < 0$
Range: $-4 \le Q(-t) \le 7$

7 Domain: $t < 0$
Range: $-7 \le -Q(-t) \le 4$

9 $y = -e^x$

13 Reflected across x-axis;
$-g(x) = -(1/3)^x$
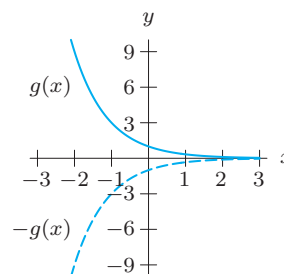
15 $-m(n) = -(n)^2 + 4n - 5$
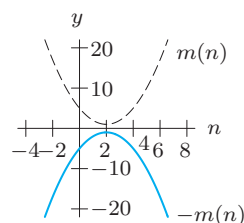
17 $m(-n) + 3 = n^2 + 4n + 8$
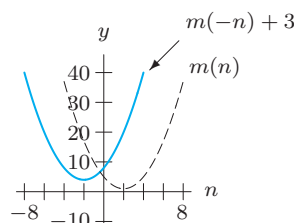
19 $-k(w) = -3^w$
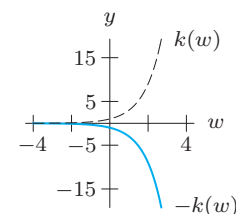
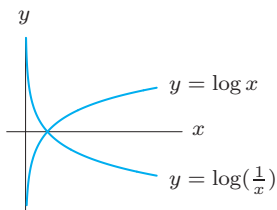21 $-k(w - 2) = -3^{w-2}$
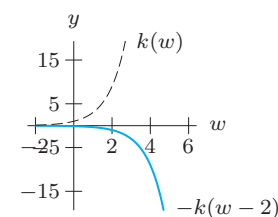
23 Odd

25 Neither

27 (a) $y = 2^{-x} - 3$
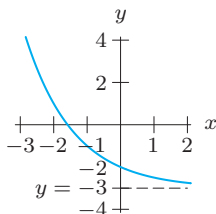
(b) $y = 2^{-x} - 3$
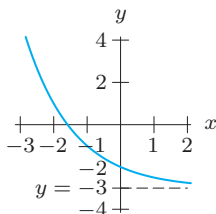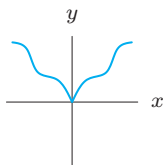

(c) Yes

29 (a) $g(-x) = -\sqrt[3]{x}$
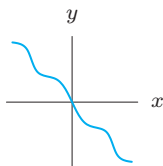   (c) Odd

31 Reflections across x-axis

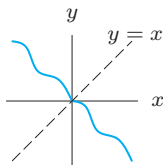33 (i)   b
    (ii) c
    (iii) d
    (iv) e
    (v)   a

35 (a)

(b)
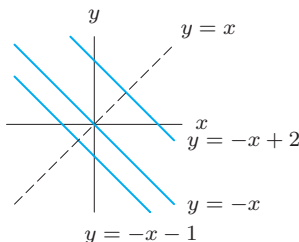

(c)

37 (a) Odd
   (b) Unless $f(x) = 0$ or $g(x) = 0$, $k(x)$ is
        neither.
   (c) Even

39 $y = x$. $y = -x + b$, where b is an arbitrary
    constant

43 No

45 If $f(x)$ is odd, then $f(0) = 0$

49 Yes, $f(x) = 0$

Section 6.3

S1 (a) 72
   (b) -18
   (c) 177
   (d) 25/4

S3 (a) $-(1/3)f(x) = -(1/3)\sqrt{x}$
   (b) $5f(-x) = 5\sqrt{-x}$
   (c) $6f(x - 8) = 6\sqrt{x - 8}$
   (d) $(1/4)f(2 - x) = (1/4)\sqrt{2 - x}$

1 $y = 10f(x - 2)$

3 $-0.25 \le 0.25C(x) \le 0.25$

5 $R(n) = -5P(n)$

7 $T(n) = 1/4P(n + 7)$
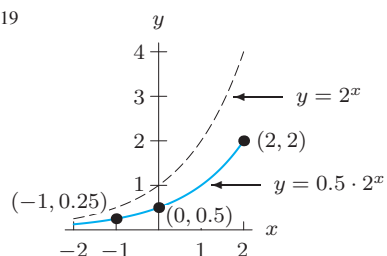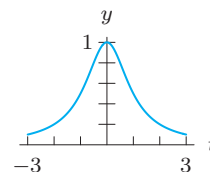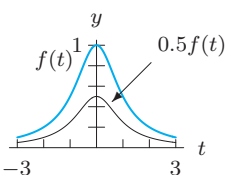
9
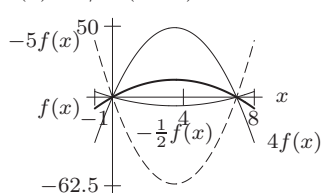
11
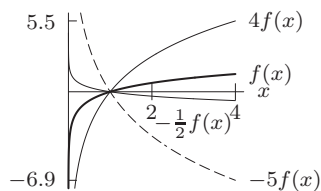
13 (d) All three

15
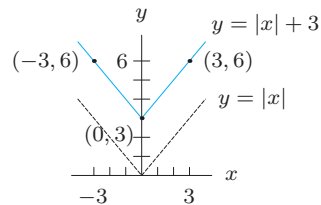
17
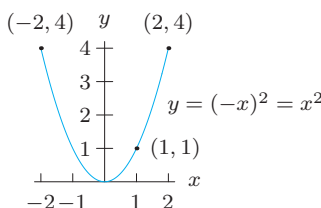
19

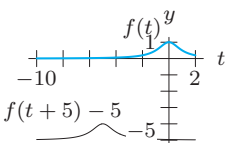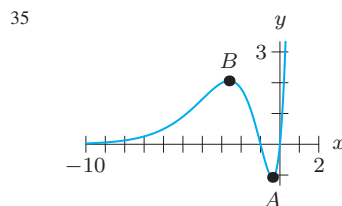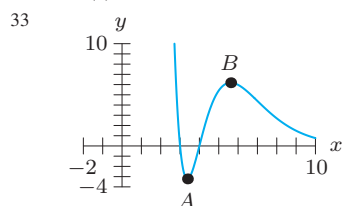21 Stretch vertically by a factor of 2, Shift left 1 unit

23

25

27

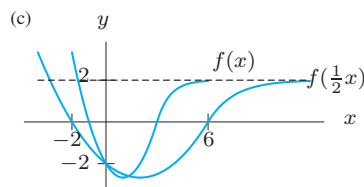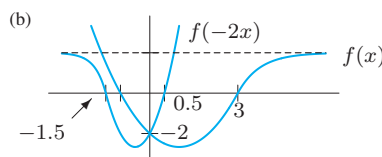29 I is (b)
    II is (d)
    III is (c)
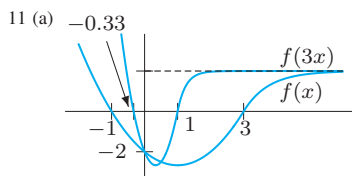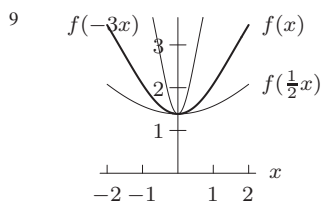   IV is (h)
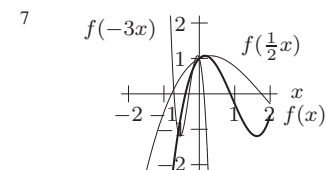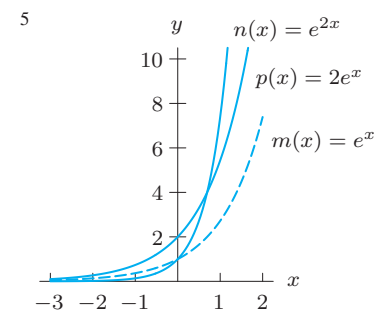
31 $1.3C(t)$

33

35

37 (a) $h(x) = 1/2 f(x)$
    (b) $k(x) = f(-x)$
    (c) $m(x) = f(x) - 4$

39 (a) $y = -2f(x)$
    (b) $y = f(x) + 2$
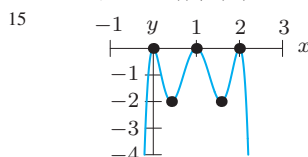   (c) $y = 3f(x - 2)$

43 -7

Section 6.4

S1 $8x^3 - 5$

S3 $(-x^3)/27 - 5$

S5 $4e^{2t}$

S7 $4e^{12t} + 11$

1 $(1, 3)$

3 Same function values for
   $x = -6, -4, -2, 0, 2, 4, 6$

5

7

9

11 (a) -0.33

(b)

(c)

13 (a) Domain: $-6 \le x \le 6$;
        Range: $0 \le l(2x) \le 3$
    (b) Domain: $-24 \le x \le 24$;
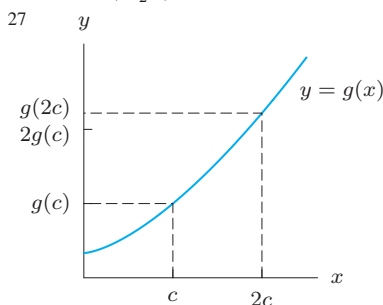   Range: $0 \le l((1/2)x) \le 3$

15

17 $T(1000x)$

19 (a) $A(s/60)$
    (b) A(60 h)

21 $r(t)$: half the level
    $s(t)$: half the rate

23 (a) III
    (b) II
    (c) I
    (d) IV

25 $y = -f(-\frac{1}{2}x)$

27

29 (a) $-24 \le x \le 8$
    (b) $-3/4$

31 (a) $-2 \le x \le 6$
    (b) 3

Section 6.5

S1 -3

S3 $10/3$
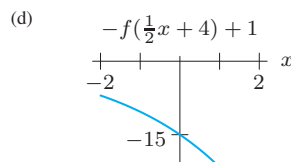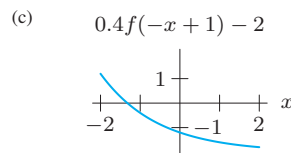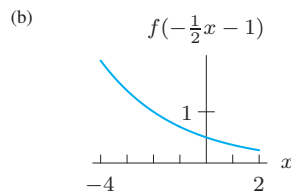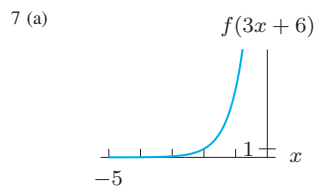
S5 (a) -1
    (b) $8\sqrt[3]{-2}$
    (c) 5
    (d) -16
    (e) $-2\sqrt[3]{2}$
    (f) $\sqrt[3]{5}$

S7 $A = 1, B = -2, h = 0, k = 9$

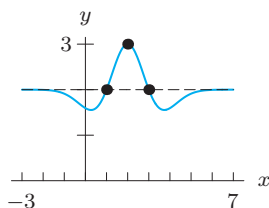S9 $A = 6, B = -1/3, h = -27, k = 0$

1 A horizontal compression by a factor of $1/3$ and
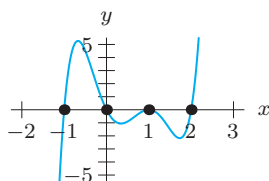   then a horizontal shift right by $2/3$ units.

3 (a) $(3, -14)$
   (b) $(6, -26)$
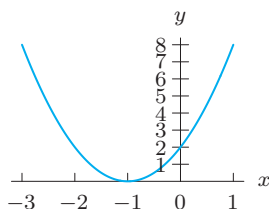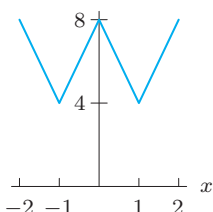   (c) $(18, 17)$
   (d) $(-33, -25/2)$

7 (a)

(b)

(c)

(d)

9

11

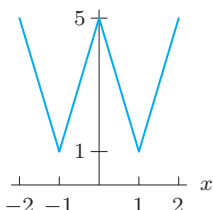**13** $t = -2.5$, $y = 5$

15
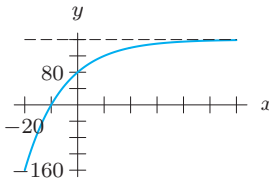

17 (a)

(b)

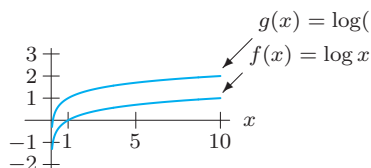**(c)** The graphs are not the same.

19 No; down 10 units

21 $g(x) = -3f(x+4) + 6$

23 $h(x) = -2f(-x+3) - 4$

25 $(-9, 7), (3, 0), (39, -4)$

27

---

29 All four transformations are equivalent.

31 (a) $+1$

$g(x) = \log(10x)$, $f(x) = \log x$

(b) $\log(10x) = 1 + \log x$

(c) $k = \log a$

33 A vertical compression by a factor of e^{-k}.

35 (a) Vertical; stretch by 2, shift by 8

(b) Vertical; shift by 4, stretch by 2

37 (b) $d(t)$ reflected about the t-axis and then raised 142

$y = c(t) = 142 - d(t)$
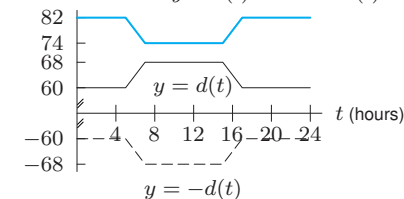
39 (a)
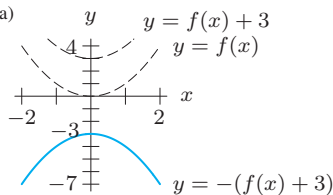
(b)
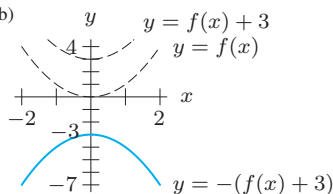
41 (a) $y = mx$, $m > 1$

(b) $y = mx + b$, $m > 1$ and b an arbitrary constant

43 Yes; $g(x) = (rb + j) + (rms) \cdot x$, $B = rb + j$, $M = rms$

45 Yes; $g(x) = (ras^2) \cdot (x - h/s)^2 + (rk + j)$, $A = ras^2$, $H = h/s$, $K = rk + j$

Chapter 6 Review

1 (a) 4

(b) 1

(c) 5

(d) -2

---

3 (a) $(6, 5)$

(b) $(2, 1)$

(c) $(1/2, 5)$

(d) $(2, 20)$

5 Odd

7 Neither

9 Even

11 (a) $f(2x) = 1 - 2x$

(b) $f(x + 1) = -x$

(c) $f(1 - x) = x$

(d) $f(x^2) = 1 - x^2$

(e) $f(1/x) = (x - 1)/x$

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

13
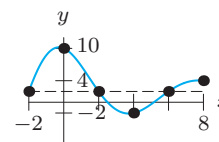
15 $y = f(t + 4) - 8$

17 (a) A horizontal reflection about the y-axis.

(b) A horizontal shift 6 units to the right.

19 (a) VI

(b) V

(c) III

(d) IV

(e) I

(f) II

21 (a) $-16t^2 + 23$
$-16t^2 + 48t + 2$

(b)
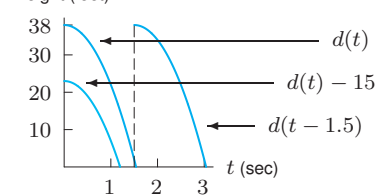
(d) 1.541 secs
1.199 secs

(e) 3.041 secs

23 $y = -(x + 1)^3 + 1$

25 $y = (1/2)h(x + 6) + 1$

27 $p \approx 15$, $q \approx 7190$

31
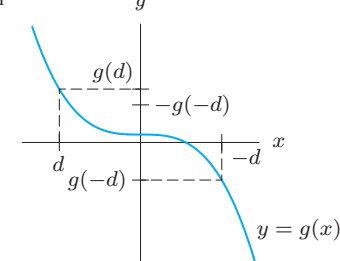
33 $y = 3h(x)$

35 $y = -h(2 - 2x)$

37 $y = 2f(x/2) + 3$

41

d	20	45	70	95
$h(d)$	5.5	5.2	5.1	5.1
d	120	145	170	195
$h(d)$	5.3	5.5	5.75	6

43

d	25	50	75	100
$n(d)$	8.25	7.8	7.65	7.65
d	125	150	175	200
$n(d)$	7.95	8.25	8.63	9

45

d	25	50	75	100
$q(d)$	10.25	9.8	9.65	9.65
d	125	150	175	200
$q(d)$	9.95	10.25	10.63	11

Ch. 6: Understanding

1 True

3 True

5 True

7 False

9 True

11 False

13 False

15 True

17 True

19 False

21 False

23 True

Section 7.1

1 (I), (II), (IV)

3 90 m

5 90 m

7 b

9 41

11 12 o'clock position; 165 m

13 6 o'clock position; 15 m

15

17

19
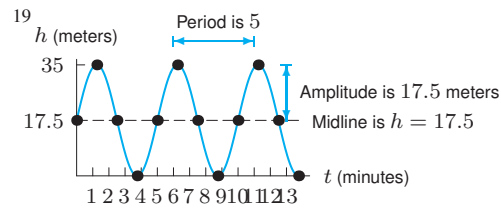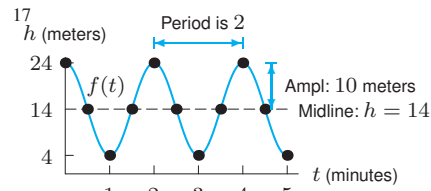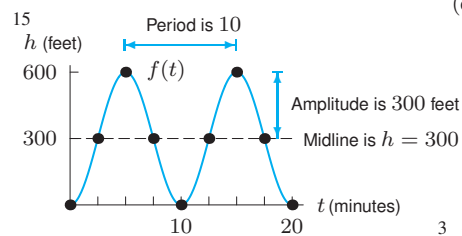
21 12 o'clock; descending; 4 minutes; 30 meters; 5 meters; 10 minutes

23 3 (or 9) o'clock; descending; 5 minutes; 40 meters; 0 meters; 11.25 minutes

27 (a) Weight B
    (b) Weight A
    (c) Weight A

29 Midline: $y = 5.55$; Amplitude: 5.15 WBC $\times 10^4$/mL; Period: 72 days

Section 7.2

1 (a) $(-0.174, 0.985)$
   (b) $(-0.940, -0.342)$
   (c) $(-0.940, 0.342)$
   (d) $(0.707, -0.707)$
   (e) $(0.174, -0.985)$
   (f) $(1, 0)$

3 $-720°$

5 $D = (0, -1)$, $E = (-0.707, -0.707)$, $F = (-0.707, 0.707)$

7 (a) 0.923
   (b) 0.385

9 (a) 0.447
   (b) 0.894

13 (a) $307°$
    (b) $127°$

15 (a)

(b)

(c)

(d)
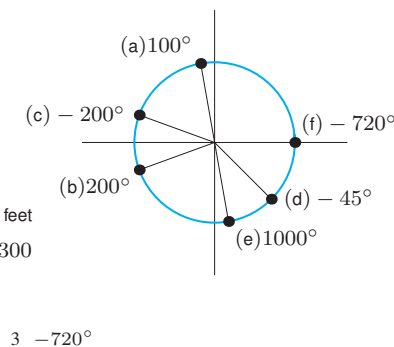
19 (a) $72°$
   (b) $180°$
   (c) $216°$

21 (a) All are equal
   (b) $KP = 1/2$
   (c) $OP = \sqrt{3}/2$
   (d) $(\sqrt{3}/2, 1/2)$
   (e) $\cos 30° = \sqrt{3}/2$;
       $\sin 30° = 1/2$
   (f) $\cos 60° = 1/2$;
       $\sin 60° = \sqrt{3}/2$

23 $d = 3\cos\alpha$ meters

Section 7.3

1 Mid: $y = 2$; Amp: 1

3 Mid: $y = -3$; Amp: 7

5 Mid: $i(t) = 223$ cm; Amp: 20 cm

7 $(0, 3.8)$

9 $(-3.8, 0)$

11 $(0, 3.8)$

13 $(3.687, -0.919)$

15 $(3.8\sqrt{2}/2, 3.8\sqrt{2}/2)$ or $(2.687, 2.687)$

17 $(-3.8\sqrt{2}/2, -3.8\sqrt{2}/2)$
   $(-2.687, -2.687)$

19 $(3.742, -0.660)$

21 $(-5\sqrt{3}, -5)$

23 period 50, midline $y = 12$, amplitude 5

25 period 24, midline $y = -500$, amplitude 2000

27 period 25, midline $y = 30$, amplitude 25

29 $g(x) = \cos x, a = 90°, b = 1$

33 $f(x) = \sin(x + 90°)$
   $g(x) = \sin(x - 90°)$

35 $(60, 0), (7.5, 0)$
   $(60\cos\theta, 60\sin\theta)$
   $(7.5\cos\theta, 7.5\sin\theta)$

37 $h(\theta) = 2.5 + 2.5\sin\theta$.

Section 7.4

1 $0, 1, 0$

3 (a) $\tan\theta = 2$
   (b) $\sin\theta = 2/\sqrt{5}$
   (c) $\cos\theta = 1/\sqrt{5}$

5 (a) $\sqrt{45}/7$
   (b) $2/7$
   (c) $\sqrt{45}/2$

7 (a) $8/12$
   (b) $\sqrt{80}/12$
   (c) $8/\sqrt{80}$

9 (a) $\sqrt{117}/11$
   (b) $2/11$

(c) $\sqrt{117}/2$

11 $r = 7\sin 17°$; $q = 7\cos 17°$

13 $r = 6/\cos 37°$; $q = 6\tan 37°$

15 $r = 9/\tan 77°$; $q = 9/\sin 77°$

17 0

19 Undefined

21 1

23 0

25 $h = 400$ feet; $x = 346.410$ feet

27 $d = 35000/\tan\theta$ feet

29 $d \approx 15.877$ feet

Section 7.5

1 $61.164°$

3 $7.012°$

5 no solution

7 $89.190°$

9 $\theta = 60°$

11 $\theta = 60°$

or 13 $\theta = 45°$

15 $c = 34.409; A = 35.538°, B = 54.462°$

17 $B = 62°; a = 9.389; b = 17.659$

19 The angle is k; a represents the value

21 The angle is c; the value is $1/d$

23 The angle is n; the value is p

25 (a) 0.009
   (b) $30°$
   (c) 114.593

27 (a) $\sqrt{2} + 1$
   (b) $2\sqrt{2} + 1$
   (c) $90.008°$

29 $\theta = 33.557°$

31 No solution

33 $9°$

35 $30°$

37 $15.859°$

39 $39.806°$

41 $\approx 39.806°$

43 (a) $a = 4; c = 2; B = 60°$
   (b) $A \approx 73.740°; B \approx 16.260°; b = 7$

Section 7.6

1 $x \approx 19.121$

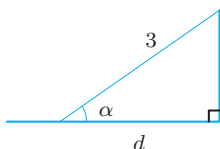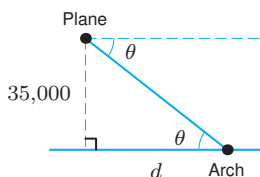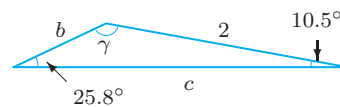3 $b \approx 5.120, c \approx 6.497; \beta = 52°$

5 $a \approx 11.818, b \approx 2.084; \theta = 80°$

7 $a = 10.450; \theta = 16.560°, \psi = 143.440°$

9 $A = 25.922°, B = 37.735°, C = 116.343°$

11 $b = 31.762, A = 38.458°, C = 60.542°$

13 $c = 10.954, A = 54.010°, B = 45.990°$

15 $c = 7.2605; A = 21.4035°; B = 126.597°$

17 $a = 15.860, b = 2.569, C = 66°$

19 $a = 10.026, b = 6.885, C = 61°$

21 $a = 2.079, b = 3.090, B = 18°$

23 $a = 1.671, b = 4.639, B = 166°$

25 $a = 13.667, A = 90.984°, C = 17.016°$

27 $a = 12.070, A = 135.109°, C = 27.891°$
   or
   $a = 3.231, A = 10.891°, C = 152.109°$

29 $b = 0.837$ m, $c = 2.720$ m; $\gamma = 143.7°$

31 $\alpha \approx 41.410°, \beta \approx 82.819°, \gamma \approx 55.771°$
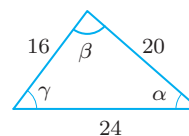
33 (a) $\sin\theta = 0.282$
   (b) $\theta \approx 16.374°$
   (c) 12.077 cm^2

35 B closer by 2.387 miles

37 396.004 miles

39 $(18.876, 10.071)$

43 (a) First; 3.062 feet closer
   (b) 157.279 feet to home
       113.218 feet to third

45 158.926 feet

47 4 rolls

Chapter 7 Review

1 Yes

3 No

5 No

7 Yes

9 $S = (-0.707, -0.707), T = (0, -1),$
   $U = (0.866, -0.5)$

270°

T

330°

U

11 $S = (-3.536, -3.536)$
   $T = (0, -5)$
   $U = (4.330, -2.5)$

13 $(4.944, -15.217)$

15 $44.971°$

17 $59.036°$

19 $\theta = 30°$

21 $\theta = 45°$

23 Angle is y; value is x

25 Angle is d; value is $1/c$

27 (a) $30°$
   (b) $-30°$
   (c) $150°$

29 (i) is B; (ii) is C; (iii) is A

31 Period: 6; Amp: 5; Mid: $y = 0$

33 Midline: $h = 2$;
   Amplitude: 1;
   Period: 1

35 419.856 feet

37 $\phi = 53.130°$; $\theta = 36.870°$

39 5; $67.380°$, $22.620°$

41 $\theta \approx 22.620°$

43 Approximately 80 meters

45 $h = 200 \tan \theta$

Ch. 7: Understanding

1 True

3 True

5 True

7 True

9 False

11 False

13 False

15 True

17 False

19 False

21 True

23 False

25 True

27 True

Ch. 7 Skills: Special Angles

1 $1/2$

3 $-\sqrt{3}/2$

5 $1/2$

7 $\sqrt{3}/2$

9 $1/\sqrt{2}$

11 $-\sqrt{3}/2$

13 $1/\sqrt{2}$

15 $-1/\sqrt{2}$

17 $-\sqrt{3}/2$

19 They are equal

21 5

23 $20/\sqrt{3}$

25 $5, 5, 5\sqrt{2}$

27 $7/\sqrt{2}, 7/\sqrt{2}, 7$

29 $45°$-$45°$-$90°$, $4\sqrt{2}$

31 $(3\sqrt{2}, -3\sqrt{2})$

Section 8.1

1 $\pi/3$

3 1.7453 radians

5 $5\pi/6$

7 $-3\pi/2$

9 $630°$

11 $16,200/\pi \approx 5156.620°$

13 $8100/\pi \approx 2578.310°$

15 (a) I
   (b) II
   (c) II
   (d) III
   (e) IV
   (f) IV
   (g) I
   (h) II
   (i) II
   (j) III

17 -4π

19 8.54π

21 $6.2\pi/4 \approx 4.869$

23 $6.2a\pi/180$

25 (a) $\sqrt{3}/2$
   (b) $-1/\sqrt{2}$
   (c) 1
   (d) $\sqrt{3}/2$

27 5π feet

29 $\pi/9$ radians or $20°$

31 $r = \sqrt{65}$; $\theta = 0.5191$ rad $= 29.7449°$;
   $s = 4.185$; $P = (7, 4)$

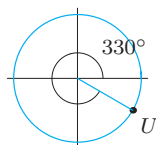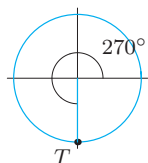33 $r = 12$; $\theta = 1.3$ rad $= 74.485°$;
   $s = 15.6$; $P = (3.2100, 11.5627)$

35 $\theta = 0.4$ rad $= 22.918°$; $P = (0.9211r, 0.3894r)$

37 (a) Negative
   (b) Negative
   (c) Positive
   (d) Positive

39 $\sin \theta = 0.6$;
   $\cos \theta = -0.8$

41 $(-0.99, 0.14)$

43 $m = 5\cos(4/5)$
   $n = 5\sin(4/5)$
   $p = 5\sqrt{2(1 - \cos(4/5))}$

45 (a) $1718.873°$
   (b) 0.00914 radians

47 7π inches

49 t

1
t
t
$\sin t$
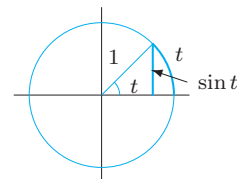
Section 8.2

1 Mid: $y = 0$; Amp: 6; Per: 2π

3 Mid: $y = 1$; Amp: $1/2$; Per: $\pi/4$

5 Hor: $-4/3$; Phs: -4

7 Both f and g have periods of 1, amplitudes of 1, and midlines $y = 0$

9 $h(t) = 4\sin(2\pi t)$

11 $g(t) = -2\cos(t/2) + 2$

13 $y = 4000 + 4000\sin((2\pi/60)x)$

15 $y = -2\sin(\pi\theta/6) + 2$

17

19

21 $f(x) = \sin x$, $a = \pi/2$, $b = \pi$,
   $c = 3\pi/2$, $d = 2\pi$, $e = 1$

23 Amplitude: 20
   Period: $3/4$ seconds
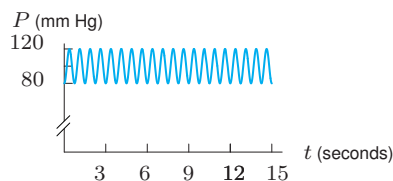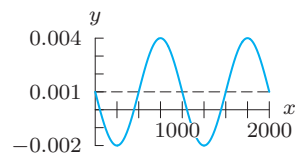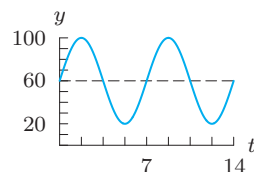
25 $3/10$, $g(x) = 10\sin((\pi/5)x - 3\pi/5)$

27 $f(t) = 14 + 10\sin(\pi t + \pi/2)$

29 $f(t) = 20 + 15\sin((\pi/2)t + \pi/2)$

31 (a) $12°/\text{min}$
   (b) $\theta = (12t - 90)°$
   (c) $f(t) =$
        $225 + 225\sin(12t - 90)°$
   (d) Amp = Midline = 225 feet
        Period = 30 min

33 (a) $P = f(t) =$
        $-450\cos(\pi t/6) + 1750$
   (c) $t_1 \approx 1.9$; $t_2 \approx 10.1$

35 $y = 3f(x)$

37 $y = -f(2x)$

39 Amplitude: 41.5;
    Period: 12 months

blanket sales (thousands)

41 $f(t) =$
    $-100\cos(\pi t) + 100$ (for $0 \le t \le 1$)
    $10\cos(4\pi t) + 190$ (for $1 < t \le 2$)

43 (a) $T(°F)$

   (b) $23.2°$; 12 months
   (c) $T = f(t) =$
        $-23.2\cos((\pi/6)t) + 58.6$
   (d) $T = f(9) \approx 58.6°$

45 (a) Not exactly regular
   (b) Usage repeats each week
   (c) $n = 45,000\cos(2\pi(t - 2)/7) + 100,000$.

Section 8.3

1 1

3 $-\sqrt{3}$

5 $-1/\sqrt{3}$

7 $-1/\sqrt{3}$

9 $2/\sqrt{3}$

11 $(\cos(2\theta))^2 + (\sin(2\theta))^2 = 1$

13 1

15 $\cos t$

17 1

19 (a) $(-x, -y)$

21 $\sec\theta = 2$
    $\tan\theta = \sqrt{3}$

23 $\sec\theta = 3/\sqrt{8}$
    $\tan\theta = 1/\sqrt{8}$

25 $f(\theta) = (1/2)\tan\theta$

27 $\cos\theta = \sqrt{1 - y^2}$

29 (a) $\sin\phi = -0.8866$, $\tan\phi = -1.9166$
   (b) $\cos\theta = -0.8062$, $\tan\theta = 0.7339$

31 $\cos\theta = \sqrt{9 - x^2}/3$,
    $\tan\theta = x/\sqrt{9 - x^2}$

33 $\sin\theta = \sqrt{4 - x^2}/2$,
    $\tan\theta = \sqrt{4 - x^2}/x$

35 (a) (i) Is identity
        (ii) Not identity
   (b) Three

37 (a) $\ldots, -3\pi/2, -\pi/2, \pi/2, 3\pi/2, \ldots$;
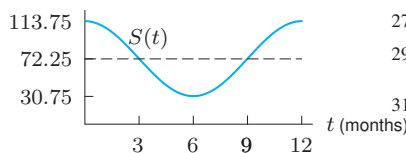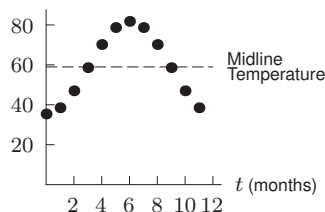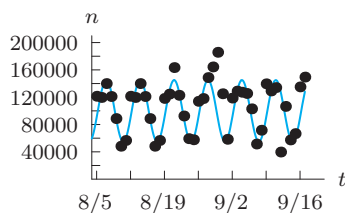   It has t-intercepts.
   (b) $\ldots, -2\pi, -\pi, 0, \pi, 2\pi, \ldots$;
        It has t-intercepts.

Section 8.4

1 1.570

3 1.330

5 -1.447

7 $\theta = 0.708, 2.434$

9 $t = 1.813, 4.473$

11 (a) 1.88, 4.41
   (b) 1.88, 4.41

13 $\pm 1.159, \pm 5.124, \pm 7.442, 11.407, 13.725$

15 $\pi/6, 5\pi/6$

17 $\pi/3, 5\pi/3$

19 $3\pi/4, 7\pi/4$

21 $0, \pi, 2\pi$

23 0.340, 2.802

25 0.152, 1.418, 3.294, 4.560

27 1.914, 4.653

29 (a) $65°, 295°$
   (b) $65°, 245°, 425°, 605°$

31 0.305, 2.837

33 4.069, 5.356, 10.352, 11.639

35 $\theta = \pi/6 + 2\pi k, 11\pi/6 + 2\pi k, k$ an integer

37 $\theta \approx 1.893$

39 $t = \pi/6, 5\pi/6,$
    $7\pi/6$, or $11\pi/6$

41 $t = \pi/2, 3\pi/2,$
    $\pi/6$, or $5\pi/6$

43 (a) $f(t) = 40,000\cos\left(\frac{\pi}{6}t + \frac{\pi}{6}\right) + 60,000$
   (b) $f(3) = \$40,000$
   (c) Mid-March and mid-September

45 $P: x \approx 0.819$;
    $Q: x \approx 3.181$

47 (a) $\pi/3$
   (b) π
   (c) ≈ 0.1

49 (a) $t_1 \approx 0.161$ and $t_2 \approx 0.625$.
   (b) $t_1 = \arcsin(3/5)/4$ and
        $t_2 = \pi/4 - \arcsin(3/5)/4$

51 (a) $\pi/3$
   (b) $2\pi/3$
   (c) $1/2$
   (d) $\pi/3$

53 (b) $t^2 = 2\sin t$ for $t = 0$ and $t \approx 1.40$
   (d) $k \approx 20$

55 $\theta = \arctan(m_1) - \arctan(m_2)$

Section 8.5

1 IV

3 II

5 III

7 I

9 IV

11 $90°$ to $180°$
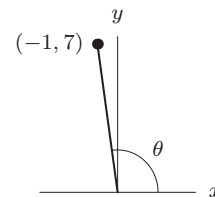
13 $180°$ to $270°$
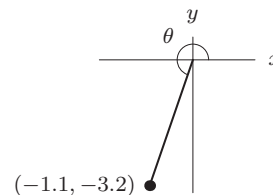
15 $(1, \pi)$

17 $(2, 5\pi/6)$

19 $(-\sqrt{6}/2, -\sqrt{6}/2)$

21 $(-\sqrt{3}, 1)$

23 $x^2 + y^2 = 6x$

25 $y = x^2 - 2x$

27 $r = \sqrt{5}$

29 $r = 1/\sqrt{2\cos\theta\sin\theta}$

31 $H: x = 3, y = 0; r = 3, \theta = 0$
    $M: x = 0, y = 4; r = 4, \theta = \pi/2$

33 $H: x = 3/2, y = 3\sqrt{3}/2; r = 3, \theta = \pi/3$
    $M: x = 0, y = 4; r = 4, \theta = \pi/2$

35 $H : x = -1.5$, $y = -3\sqrt{3}/2$; $r = 3$,
$\theta = 4\pi/3$
$M : x = 0$, $y = 4$; $r = 4$, $\theta = \pi/2$

37 $H : x \approx -2.974$, $y \approx 0.392$; $r = 3$,
$\theta = 172.5\pi/180$
$M : x = 4$, $y = 0$; $r = 4$, $\theta = 0$

39 $0 \le r \le 2$ and $-\pi/6 \le \theta \le \pi/6$

41 (b)

(c) Cartesian:
$(\sqrt{3}/4, 1/4)$;
$(-\sqrt{3}/4, 1/4)$ or polar:
$r = 1/2$, $\theta = \pi/6$ or $5\pi/6$

(d)

43 Looks the same

45 Rotated by $90°$ clockwise

47 $\pi/4 \le \theta \le 5\pi/4$;
$0 \le \theta \le \pi/4$ and $5\pi/4 \le \theta \le 2\pi$

Section 8.6

1 $5e^{i\pi}$

3 $0e^{i\theta}$, for any θ.

5 $5e^{i4.069}$

7 $-5 + 12i$

9 $-3 - 4i$

11 $-\frac{1}{2} + i\frac{\sqrt{3}}{2}$

13 $\frac{\sqrt{3}}{2} + \frac{i}{2}$

15 $\sqrt{2} + i\sqrt{2}$

17 $\frac{\sqrt{3}}{2} + \frac{i}{2}$

19 $\sqrt{2}/2 + i\sqrt{2}/2$

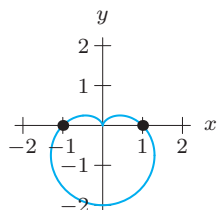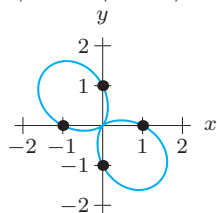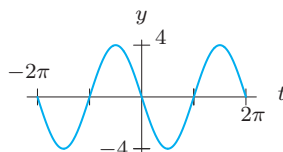21 $\sqrt{2} \cos \frac{\pi}{12} + i\sqrt{2} \sin \frac{\pi}{12}$

23 $2.426 + 4.062i$

25 $A_1 = 2 - i$
$A_2 = -2 + 2i$

27 (a) $e^{i\pi/2}$

33 $2e^{\pi i/3} = 1 + 1.732i$, $2e^{\pi i} = -2$,
$2e^{5\pi i/3} = 1 - 1.732i$

35 $2^{1/6}e^{\pi i/12} = 1.084 + 0.291i$,
$2^{1/6}e^{3\pi i/4} = -0.794 + 0.794i$,
$2^{1/6}e^{17\pi i/12} = -0.291 - 1.084i$

37 1

39 $(\sqrt{2})/2 + i(\sqrt{2})/2$

Chapter 8 Review

1 $11\pi/6$

3 $-5\pi/4$

5 $270°$

7 $900/\pi = 286.479$

9 -12π

11 (a) II
(b) III
(c) IV
(d) I
(e) III

13 $3 \cos 2A$

15 $6.2 \cdot 13\pi/4 \approx 63.303$

17 (a) $C(t)$
(b) $D(t)$
(c) $A(t)$
(d) $B(t)$

19 Mid: $y = 7$; Amp: 1; Per: 2π

21 I

23 I

25 $(1.571, 0)$

27 $(0, 0)$

29 Amplitude: 4
Period: 2π
Phase shift: 0
Horizontal shift: 0

31 Amplitude: 1
Period: π
Phase shift: $-\pi/2$
Horizontal shift: $-\pi/4$ (left)
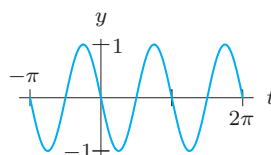
33 Amp: 30; mid: $y = 60$; per: 4

35 Amp: 40; mid: $y = 50$; per: 16

37 $y = \sin x$ for $f(x)$, $k(x)$; $y = \cos x$ for
$g(x)$, $h(x)$

39
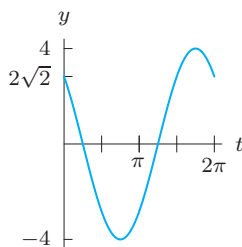
41
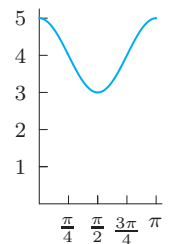
43 Appear to be same
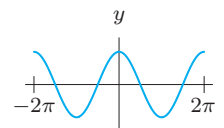
45 (a) OE
(b) OA
(c) DB
(d) OF
(e) OC
(f) GH

47 $-1/2$

49 $\tan \theta = -3/4$

51 1.168

53 (a) $y = (-1/\sqrt{3})x + 2$
(b) $2\sqrt{3}$

55 (a)
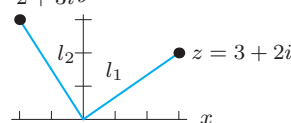
57 (a) $y = 600 - 300 \cos(2\pi x/80)$
(b) $x = 14.5279, 65.4721, 94.5279$

59 $f_1(x) = 6 \cos((1/2)(x - 3\pi)) + 2$,
$f_2(x) = -6 \cos((1/2)(x - \pi)) + 2$,
$f_3(x) = 6 \sin((1/2)(x - 2\pi)) + 2$,
$f_4(x) = -6 \sin((1/2)x) + 2$;
answers may vary

61 $f_1(x) = 5 \cos((\pi/6)(x + 2)) + 3$,
$f_2(x) = -5 \cos((\pi/6)(x - 4)) + 3$,
$f_3(x) = 5 \sin((\pi/6)(x - 7)) + 3$,
$f_4(x) = -5 \sin((\pi/6)(x - 1)) + 3$;
answers may vary

63 $\pi/6$, $7\pi/6$

65 0.616, 2.526, 3.757, 5.668

67 69.115 miles

69 $0.516°$

71 0.1345 radians

73 $f(t) = -900 \cos((\pi/4)t) + 2100$

75 $y = 30\sin(10.5t - \pi/2) + 150$

Ch. 8 Understanding

1 False

3 False

5 False

7 True

9 False

11 True

13 False

15 True

17 False

19 True

21 True

23 True

25 False

27 False

29 False

31 False

33 True

35 True

37 True

39 True

41 True

43 False

45 True

47 False

49 True

51 False

53 True

55 False

57 True

59 False

61 True

63 False

65 False

67 False

69 True

71 True

73 False

75 True

77 True

79 True

Section 9.1

1 $\sin t - \cos t$

3 $\cos t + 3\sin t$

5 $2\sin\alpha$

7 $\cos t - \sin t$

9 0

11 $\tan\sqrt{\theta}$

13 $(3/4)\tan(\phi + 1)$

15 $(10/3)\tan\left(\dfrac{2}{k+3}\right)$

17 $\cos^2\theta + \sin^2\theta = 1$;
   $\cos 2\theta = \cos^2\theta - \sin^2\theta$
   $= 2\cos^2\theta - 1 = 1 - 2\sin^2\theta$

27 $\pi/6, 5\pi/6, \pi/2, 3\pi/2$

29 $0, \pi/3, 2\pi/3, \pi, 4\pi/3, 5\pi/3, 2\pi$

31 Not an identity

33 Not an identity

35 Not an identity

37 Identity

39 Identity

41 Identity

43 Not an identity

45 Not an identity

47 (a) $\theta = 60°$, $180°$, and $300°$
   (b) $\theta = \frac{7\pi}{6}, \frac{3\pi}{2}, \frac{11\pi}{6}$

49 (a) $\sqrt{1 - y^2}$
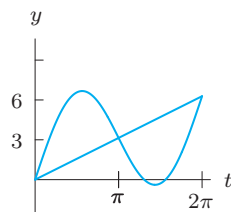   (b) $y/(\sqrt{1 - y^2})$
   (c) $1 - 2y^2$
   (d) y
   (e) $1 - y^2$

51 $\sin 2\theta = \frac{2x}{9}\sqrt{9 - x^2}$

53 (a) $2x\sqrt{1 - x^2}/(2x^2 - 1)$
   (b) $2x/(1 + x^2)$

55 $\sin 4\theta = 4(\sin\theta\cos\theta)(2\cos^2\theta - 1)$

61 $\cos\left(\cos^{-1}\left(\frac{1}{2}\right)\right) = \frac{1}{2}$;
   $\cos^{-1}\left(\cos\left(\frac{5\pi}{3}\right)\right) = \frac{\pi}{3}$

Section 9.2

1 $10\sin(t - 0.644)$

3 $\sqrt{2}\sin(t + 3\pi/4)$

5 $\sin 15° = \cos 75° = (\sqrt{6} - \sqrt{2})/4$
   $\cos 15° = \sin 75° = (\sqrt{6} + \sqrt{2})/4$

7 $\sqrt{6}/2$

9 $(\sqrt{6} + \sqrt{2})/4$

11 (a) 1.585
   (b) 0.053
   (c) 1.216
   (d) -0.069

19 $x = 2\pi/5, 4\pi/5, 6\pi/5,$
   $8\pi/5, \pi/3, \pi, 5\pi/3$

Section 9.3

1 All integral multiples of π

3 (a) $P = 5000 + 300t$
   (b) $P = 3200(1.04)^t$

(c) $P(t) = -900\cos(2\pi t/5) + 2100$

5 (a) $m = 2.5; b = 20; A = 10$
   (b) Roughly in January and December
   (c) Roughly between May and September

7 (a) $y = 1$
   (b) f oscillates faster and faster between -1 and 1 as t increases.
   (c) ≈ 0.540
   (d) $t_1 = \ln(\pi/2)$
   (e) $t_2 = \ln(3\pi/2)$

11 (a) $h = f(t)$
   $= 25 + 15\sin(\pi t/3) + 10\sin(\pi t/2)$
   (b) $f(t)$ is periodic with period 12
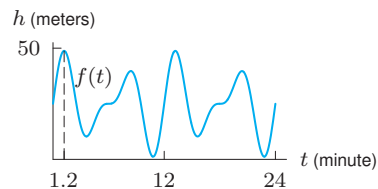
(c) $h = f(1.2) = 48.776$ m

Chapter 9 Review

1 $1 - \cos t - \sin t$

3 $4\tan t$

5 $\tan t$

7 $\cos t - \sin t$

9 $\sin\theta$

11 $2\cos\phi$

13 Both are right

15 (a) y
   (b) $y/\sqrt{1 + y^2}$
   (c) $\tan^{-1} y$
   Other answers possible
   (d) $2y/(1 + y^2)$

17 $\cos\theta = \sqrt{8835}/94$
   $\tan\theta = 1/\sqrt{8835}$

19 No; the ratio is $3/4$

21 $\theta = \pi/6, 5\pi/6$, and $3\pi/2$

23 $120/169$

29 $1.231, 5.052, \pi$

31 $\cos 3\theta = 4\cos^3\theta - 3\cos\theta$

33 $\sin(\ln(xy)) \approx 0.515$

35 (a) P_2
   (b) P_2
   (c) P_1
   (d) P_2

Ch. 9 Understanding

1 True

3 True

5 True

7 True

9 True

11 False

13 True

15 True

17 True

19 False

21 True

23 False

25 True

27 False

29 True

Section 10.1

1 $2^{x/(x+1)}$
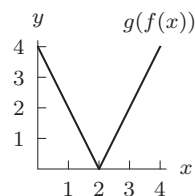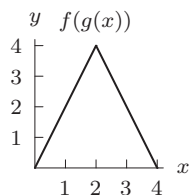
3 $\sin(4\sqrt{x})$; $\sqrt{\sin 4x}$

5 $w(x) = 4x + 3$

7 $s(0) = 2, s(1) = 5, s(2) = 8,$ $s(3) = 3, s(4) = 1, s(5) = 4$

9 $9x$

11 $27x^2 - 2$

13 $3888x^2 - 1728x + 192$

15 $\ln(x^2 + 4)$

17 $\cos 2x$

19 Area in terms of time

21 Revenue in terms of fertilizer

23 $u(x) = 1/(x-1),$ $v(x) = x^2$

25 $g(x) = \sqrt{x}, h(x) = 1 + \sqrt{x}$
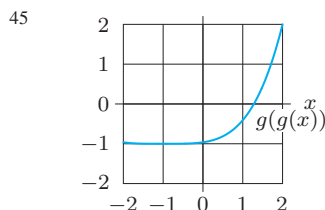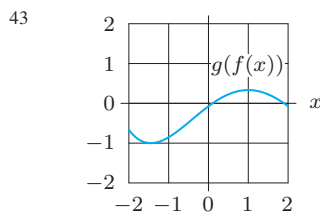
27 $g(x) = 1/x^2, h(x) = x + 4$

29

x	$f(x)$	$g(x)$	$h(x)$
0	2	1	3
1	1	0	0
2	4	3	2
3	0	4	1
4	3	2	4

31 $f(x) = 2x$

33 $f(x) = \ln x$

35 $(\sqrt{x+h} - \sqrt{x})/h$

37 $(2^{x+h} - 2^x)/h$

39 (a) 4
(b) 1
(c) 4
(d) 0

41 (a)

(b) $0 < x < 2$
(c) $2 < x < 4$

43

45

47 $v(x) = x + 1/x$

49 (a) $u(x) = (1 + x)/(2 + x)$
(b) $u(x) = x/(1 + x)$

51 (a) $v(x) = -x$
(b) $u(x) = \sqrt{1-x}$

53 (a) $v(x) = \sin x$
(b) $u(x) = \sin^2(\sqrt{x})$

55 (a) (i) 3
   (ii) 4
   (iii) 3
   (iv) 4
(b) 5

57 $1/2$

59 All real numbers;
All real numbers greater than or equal to zero

61 $q(x) = 2^x$

63 $g(x) = -1$, provided $x \neq -3$

65 (a) and (e)

Section 10.2

1 Not invertible

3 Not invertible

5 Not invertible

11 Yes, $f(f^{-1}(x)) = f^{-1}(f(x)) = x$

13 Yes, $f(f^{-1}(x)) = f^{-1}(f(x)) = x$

15 $f^{-1} = x - 5$

17 $h^{-1} = x^2$

19 $f^{-1}(x) = (x + 7)/3$

21 $l^{-1} = \sqrt{(1-x^2)/2}$

23 $n^{-1} = \sqrt{\sqrt{x} - 1}$

25 $j^{-1}(x) = (x^2 - 1)^2$

27 $k^{-1}(x) = (3 - 2x)^2/(x+1)^2$

29 $h^{-1}(x) = (5 + 4 \cdot 10^x)/(10^x - 1)$

31 $g^{-1}(x) = \arcsin(\ln x / \ln 2)$

33 Time at which pop is P; years

35 (a) $f^{-1}(R) = (1/5)R - 30$

37 (a) $f(3) = 5^3 = 125; f^{-1}(\frac{1}{25}) = -2$

(b) $f^{-1}(10) \approx 1.43086$

39 $f^{-1}(3) < f(3) < 0 < f(0) < f^{-1}(0) <$ 3

41 $f^{-1}(P) = 50 \ln(P/10)$

43 (a) $f(t) = 800 - 14t$ gals
(b) (i) 800 gals

  (ii) 57.143 days

  (iii) 28.571 days

  (iv) 14t

45 (a) $f(g(x)) = g(f(x)) = x$; inverses
(b) Line $y = x$

47 (a) $P(t) = 150(1.1)^t$
(b) $P^{-1}(N) =$ $(\log(N) - \log(150))/(\log(1.1))$
(c) 10.3 years

49 (a) $H(t) = 200e^{-1.15129t}$
(b) Dropped 50.021°C in the first 15 mins, 37.532°C in the next 15 mins
(c) $H^{-1}(y) = -\ln(y/200)/1.15129$
(d) About 3 hours and 12 minutes
(e) Brick's temperature approaches room temperature

51 $f^{-1}(x) = \left(0.5x^{-1} - A^{-1}\right)^{-1}$

53 $W(-1/e) = -1, W(0) = 0, W(e) = 1$

55 (a) $f(t) = 7.112(1.08998)^t$
(b) $f^{-1}(P) =$ $(\log(P/7.112))/(\log 1.08998)$
(c) $f(25) = 61.299$ $f^{-1}(25) = 14.590$

57 (a) $C(0) = 99\%$
(b) $C(x) = (99 - x)/(100 - x)$
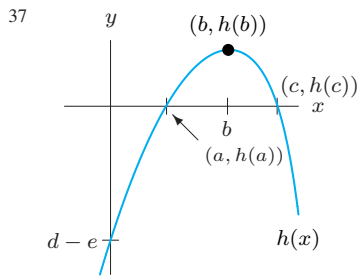(c) $C^{-1}(y) = (99 - 100y)/(1 - y)$
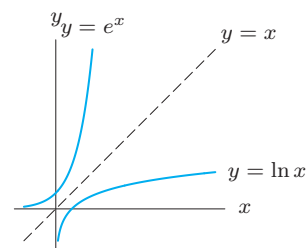
Section 10.3

1 (a) $f(x) + g(x) = 3x^2 + x + 1$
(b) $f(x) - g(x) = -3x^2 + x + 1$
(c) $f(x)g(x) = 3x^3 + 3x^2$
(d) $f(x)/g(x) = (x + 1)/(3x^2)$

3 (a) $f(x) + g(x) = 2x$
(b) $f(x) - g(x) = 10$
(c) $f(x)g(x) = x^2 - 25$
(d) $f(x)/g(x) = (x + 5)/(x - 5)$

5 (a) $f(x) + g(x) = x^3 + x^2$
(b) $f(x) - g(x) = x^3 - x^2$
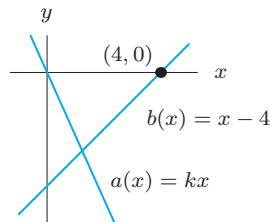(c) $f(x)g(x) = x^5$
(d) $f(x)/g(x) = x$

7 $f(x) = x$

9 $h(x) = 7x - 5$

11 $k(x) = 1 - 2x + x^2$

13 $f(x) = e^x(2x + 1) = 2xe^x + e^x$

15 $h(x) = 4e^{2x} + 4e^x + 1$

17 $\sin x + x^2$

19 $(\sin x)/x^2$

21 $\sin^2 x$

25 (a) $p(t) = f(t) + g(t)$
(b) $m(t) = g(t) \cdot h(t)$

27 4550

31

35 $17.50

37
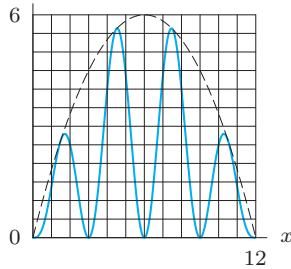
39 (a) Yes

(b) The function has no zeros

41 $H(x) = (e^{-x^2})/(x^4)$,
$h(x) = (-2x^5 e^{-x^2} - 4x^3 e^{-x^2})/(x^8)$

43 (b) $p(t) = (f_{CA}(t) \cdot g_{CA}(t) + f_{FL}(t) \cdot g_{FL}(t))/(f_{US}(t) \cdot g_{US}(t))$

45 40

47 $g(2000) = 100$, the dollar cost per square foot for building 2000 square feet of office space

49 $g(q) < g(p) < f(p) < f(q)$

51 $j(x) = x/h(x)$

Chapter 10 Review

1 2^{x^2}; 4^x

3 $1/(x^2 - 2)$

5 $\sqrt{x^2 + 1}$

7 $1/(x - 2)$

9 (a) Not invertible
(b) Not invertible
(c) Invertible

11 $h^{-1}(x) = x/(1 - 2x)$

13 $g^{-1}(x) = \frac{1}{3} \ln(x - 1)$

15 $h^{-1}(x) = \frac{1}{2}(1 - e^x)$

17 $g^{-1}(x) = (3x + 2)/(1 - 2x)$

19 $f^{-1}(x) = (11x - 3)^2/(1 + x)^2$

21 $s^{-1}(x) = 10^{(3/x)-2}$

23 Not invertible

25 Not invertible

27 $r^{-1}(y) = \ln(y + 7)$

31 $2e^x - 1$

33 $4x - 3$

35 $\sqrt{x}e^{2x-1}$

37 (a) $f(2x) = 4x^2 + 2x$
(b) $g(x^2) = 2x^2 - 3$
(c) $h(1 - x) = (1 - x)/x$
(d) $(f(x))^2 = (x^2 + x)^2$
(e) $g^{-1}(x) = (x + 3)/2$
(f) $(h(x))^{-1} = (1 - x)/x$
(g) $f(x)g(x) = (x^2 + x)(2x - 3)$
(h) $h(f(x)) = (x^2 + x)/(1 - x^2 - x)$

39 $x/(1 + e^{2x})$

41 $3x^2 + x$

43 $2x\sqrt{x + 2}$

45 $3x/2 - 1/2$

47 $x^{3/2} \tan 2x$

49 $\tan((3x - 1)^2/2) - 27x^{3/2}$

51

t	$p(t)$	$q(t)$	$r(t)$
0	4	3	5
1	5	2	1
2	3	4	0
3	2	0	4
4	1	5	2
5	0	1	3

53 $u(x) = \sqrt{x}, v(x) = 3 - 5x$

55 $u(x) = x^2, \quad v(x) = \sin x$

57 $u(x) = x^3, v(x) = 2x + 5$

59 $u(x) = 3^x, v(x) = 2x - 1$

63 (a) $r(x) = (x - 1)/(x - 2)$
(b) $s(x) = x + 1$ and $t(x) = 1/x$
(c) $p(p(a)) = (2a + 1)/(a + 1)$

65

x	$f(x)$	$g(x)$	$h(x)$
0	9	1	0
1	0	2	1
2	1	0	9

67 (a) $f^{-1}(P) = 2.5P - 50$
(b)

t	$P = f(t)$
0	20
5	22
10	24
15	26
20	28

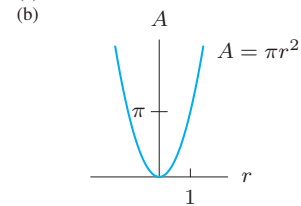| P	$t = f^{-1}(P)$
20	0
22	5
24	10
26	15
28	20

69 Velocity for time t; mph

71 $1 - t^2$

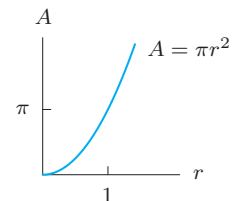73 $x = (\ln 3/ \ln 2) - 5$

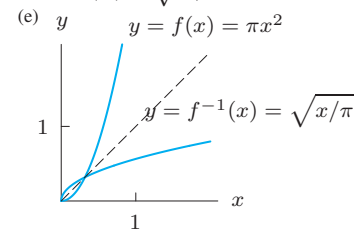75 $x = e^{1.8} - 3$

77 $x = (19 - \sqrt{37})/2$

79 (a) $A = \pi r^2$
(b)

(c) $r \geq 0$
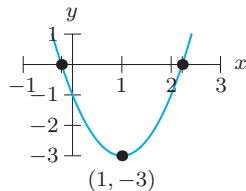

(d) $f^{-1}(A) = \sqrt{A/\pi}$
(e)

(f) Yes

81 (a) $f(g(a)) = a$
(b) $g(f(c)) = b$
(c) $f^{-1}(b) - g^{-1}(b) = -c$
(d) $0 < x \le a$

83 $2\sqrt{x} - 9$
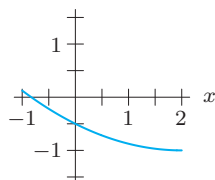
85 $(3 \pm \sqrt{17})/4$
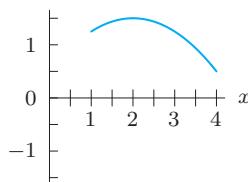
87

$(1, -3)$

89 (a) Only to $(u(x))^2$.
(b) $u((v(x))^2)$ and $u(w(v(x)))$
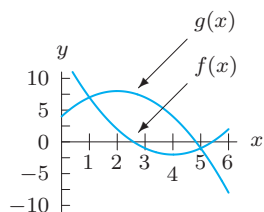(c) (i) $1 + \sin 2x$
     (ii) 1
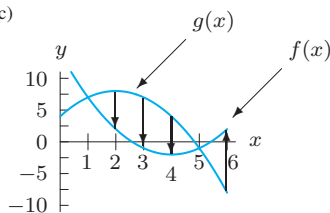   (iii) $\cos(x^2) + \sin(x^2)$
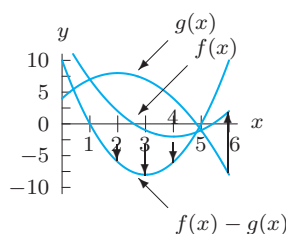
91 $y = f(g(x))$
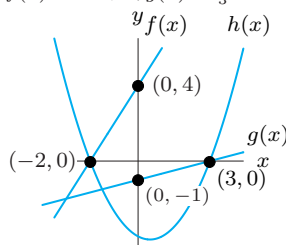
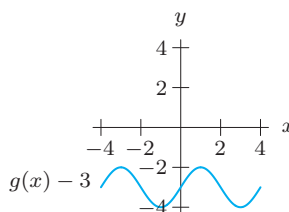93 $y = g(f(x - 2))$

95 (a)

(c)

(f) $f(x) = x^2 - 8x + 14$;
$g(x) = -x^2 + 4x + 4$;
$f(x) - g(x) = 2x^2 - 12x + 10$
(g) Yes

$f(x) - g(x)$

97 (a) $f(x) = 2x + 4, g(x) = \frac{1}{3}x - 1$
(b)

99 (a)

(b)
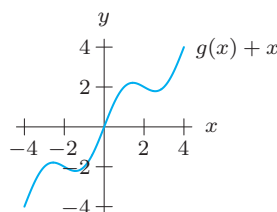
101 False

103 $g(x) = (x + 2)/2 = 0.5x + 1$

105 (a) $f(x) = e^x, g(x) = 6x, G(x) = 3x^2$
(b) $f(x) = \sin x, g(x) = -1/(2\sqrt{x})$,
$G(x) = \sqrt{x}$

107 (a) True
(b) False
(c) False
(d) True

109 Increasing

111 Can't tell

113 (a) $f(8) = 2, f(17) = 2$,
$f(29) = 2, f(99) = 0$
(b) $f(3x) = 0$

(c) No
(d) $f(f(x)) = f(x)$
(e) No

115 $f^{-1}(L) = -\frac{1}{k}\ln(1 - L/L_\infty)$
$f^{-1}(L) = $ Age of fish of length L
Domain: $0 \le L \le L_\infty$

Ch. 10 Understanding

1 False
3 True
5 True
7 True
9 True
11 False
13 False
15 True
17 False
19 False
21 False
23 False
25 True
27 True
29 True
31 False
33 True
35 True
37 True

Section 11.1

S1 $6|t|$
S3 $0.16x^2y^4$
S5 $x = 0.585$
S7 False
S9 False
1 Yes; $g(x) = (-1/6)x^9$
3 No
5 Not a power function
7 $y = \frac{48}{30625} \cdot x^{-2}, a = \frac{48}{30625}, p = -2$
9 Even
11 Fractional
13 $y = 3x^{1.058}$
15 $f(x) = (3/2) \cdot x^{-2}$
17 $k = 5; c = 5d^2; c = 125$
19 $k = 3/2; y = (3x)/2; x = 5.33$
21 $f(x) = 3x^2$
23 $j(x) = 2x^3$
25 (a) 0
   (b) 0
29 (a) $x^{-3} \to +\infty, x^{1/3} \to 0$
   (b) $x^{-3} \to 0, x^{1/3} \to \infty$
31 Formula not unique
33 v, w, f, g
35 $f(x) = -1/(3\sqrt[3]{7}) \cdot x^{-4/3}$
37 (a) $C(x) = kx$
   (b) $k = 9.5; C(x) = 9.5x$

(c)

cost ($)
$C(x) = 9.5x$
50
x (yards)
5
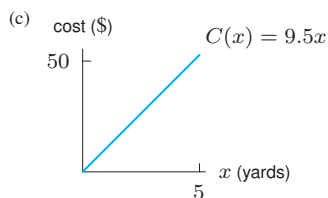
(d) $52.25

39 (b) 16 times greater

41 $P = k/\sqrt{\rho}$

43 $h = 192.5/v$; 64.167 mph

45 (a) $d = 1.7, 3.4, 20.4, 102$
$d = 0.34t$
(b) 9.8 mins
(c) $A = 9.1, 36.3, 1307, 32685$
$A = 0.363t^2$
(d) $P = 11.25t^2$
(e) 298 sec, or approx 5 min

P
3000000
2000000
1000000
t (sec)
100 300 500

47 (a) $t = 4875/w$
(b) 19.5, 16.25, 9.75, 7.5 mins
(c) t (mins)

20
10
w (watts)
500 1000

(d) 1 min

49 (a) p even: all positive real numbers
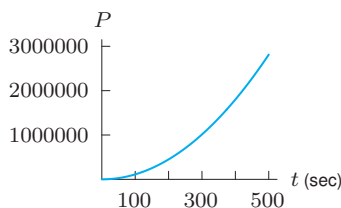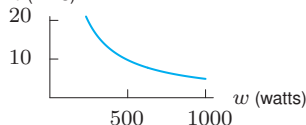p odd: all nonzero real numbers
(b) p even: symmetric about the y-axis
p odd: symmetric about the origin.
(c) p even: $y \to \infty$ as $x \to 0^-$ or $x \to 0^+$
p odd: $y \to -\infty$ as $x \to 0^-$ and $y \to \infty$
as $x \to 0^+$
(d) $y \to 0$ as $x \to \pm\infty$

51 (a) $p < 0, x \ne 0$
(b) $p > 0, y \ge 0$;
$p < 0, y > 0$;
$p > 0, y$ is any real;
$p < 0, y \ne 0$
(c) p even: y-axis symmetry;
p odd: origin symmetry

Section 11.2

1 No

3 Yes, 2

5 No

7 Degree: 3; Terms: 3;
$x \to -\infty: y \to -\infty$;
$x \to +\infty: y \to +\infty$

9 Degree: 3; Terms: 4;
$x \to -\infty: y \to +\infty$;
$x \to +\infty: y \to -\infty$

11 $x \approx 0.718, x \approx 1.702$.

15 $y = \frac{1}{2}x - 1$

17 (a) $-3 \le x \le -1, -5 \le y \le 5$
(b) $-3 \le x \le 4, -35 \le y \le 15$
(c) $1.25 \le x \le 2.35, -0 \le y \le 6$
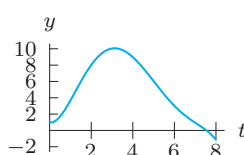(d) $-8 \le x \le 8, -50 \le y \le 2000$

19 $-1.1 \le x \le -0.9, -0.121 \le y \le 0.081$

21 $-20 \le x \le 20, -7600 \le y \le 8400$
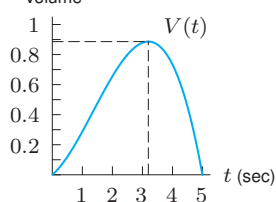
23 $-1.764 < x < 0.875$, or $x > 3.889$

25 (a)

y
10
8
6
4
2
t
-2 2 4 6 8

(b) 100 people
(c) July of 1897
(d) 1010; February of 1893
(e) -115.7; not reasonable

27 (a)

Volume
1
0.8
0.6
0.4
0.2
$V(t)$
t (sec)
1 2 3 4 5

(b) $V \approx .886$ at $t \approx 3.195$
(c) $(0, 0)$ and $(5, 0)$;
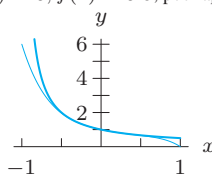Lungs empty at beginning and end

29 Yes

31 (a) False
(b) False
(c) False
(d) True

33 (a) $p(0.5) \approx 0.65625$; 2 dec pl
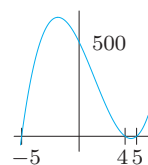(b) $p(1) = 0, f(1) = 0.5$; poor approx
(c)

y
6
4
2
x
-1 1

Section 11.3

1 $0, -4, -3$

3 $-3, 2, -7$

5 $h(x) = x(x + 2)^2(x - 3)$

7 $f(x) = (x + 2)(x - 2)^3$

9 $y = (-1/8)(x + 2)(x - 2)^2(x - 5)$;
$y = (-1/20)(x + 2)(x - 2)(x - 5)^2$

11

500
-5 4 5

13 (a) $f(x) = (x + 5)(x + 1)(2x - 1)(x - 1)$
(b) $-7 \le x \le 2, -150 \le y \le 10$

15 C

17 $f(x) = 1$

19 $f(x) = -\frac{1}{2}(x + 3)(x - 1)(x - 4)$

21 $p(x) = x^2 + 2x - 3$

23 $f(x) = -(x + 1)(x - 1)^2$

25 $f(x) = kx^3(x + 1)(x - 2)$ for $k > 0$

27 $f(x) = 3x(x + 1)(x - 1)^2$

29 $h(x) = (x + 2)(x + 1)^2(x - 1)$

31 $g(x) = -\frac{1}{3}(x^2)(x + 2)(x - 2)$

33 $x = \pm\frac{1}{2}$

35 $6, 2, 3$

37 None

39 $r = -1, s = 2, g(x) = k(x + 5)^2$ or
$r = -5, s = 2, g(x) = k(x + 5)(x + 1)$,
$k \ne 0$

41 (a) $V(x) = x(6 - 2x)(8 - 2x)$
(b) $0 < x < 3$
(c) y

25
20
15
10
5
$V(x) = x(6 - 2x)(8 - 2x)$
x
1 2 3
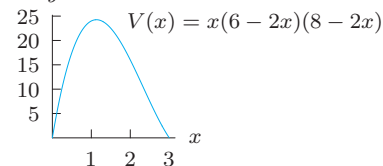
(d) ≈ 24.26 in^3

43 7.83 by 5.33 by 1.585 inches

45 $x \ge c$ and $a \le x \le b$

47 (a) $f(x) = \frac{2}{15}(x + 2)(x - 3)(x - 5)$
(b) $f(x) = -\frac{2}{75}(x + 2)(x - 3)(x - 5)^2$
(c) $f(x) = \frac{1}{15}(x + 2)^2(x - 3)(x - 5)$

Section 11.4

S1 $(6y^2 + 7)/y^3$

S3 $x^3/2$

S5 $(-18x^2 + 18x + 41)/((x - 2)^2(x + 1))$

S7 $1/2$

S9 $1/(x - 1)$

1 Rational; $(x + 2)/(x^2 - 1)$

3 Rational; $(x^3 + 2)/(2x)$

5 Not rational

7 Not rational

9 ∞

11 0

13 $y = 1$

15 As $x \to \pm\infty, f(x) \to 1, g(x) \to x$, and
$h(x) \to 0$

19 (a)
$y = f(t)$

(c) Approaches 1
(d) About 3.73 weeks

21 (a) $f(x) = (3 + x)/(12 + x)$
(b) (i) 28%
(ii) 25%
(iii) $\approx 18.2\%$
(iv) 6
(v) -3

(c) concentration of copper in alloy

(d)
$y = 1$

23 2011; Never

25 (a) $f(x) = x/(x + 5)$
(b) $f(7) = 7/12 \approx 58.333\%$
(c) $x = 0$
(d) $y = 1$

27 (a) $C(n_0)/n_0$
(b) Slope is average cost for n_0 units

29 (a) $C(x) = 30000 + 3x$
(b) $a(x) = 3 + 30000/x$
(c)
$y = a(x)$
$y = 3$

(f) $a^{-1}(y) = 30000/(y - 3)$
(g) 15,000
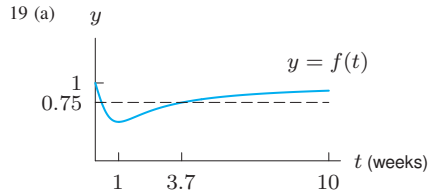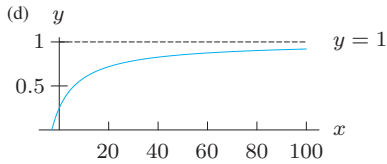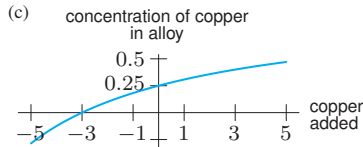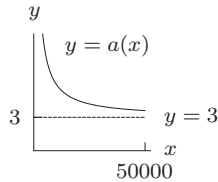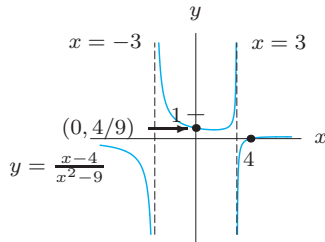
Section 11.5

1 Zeros: $x = 4$;
Asymptote: $x = \pm 3$;
$y \to 0$ as $x \to \pm\infty$

$y = \frac{x-4}{x^2-9}$

3 Zero: $x = -3$;
Asymptote: $x = -5$;
$y \to 1$ as $x \to \pm\infty$

$y = \frac{x+3}{x+5}$
$y = 1$
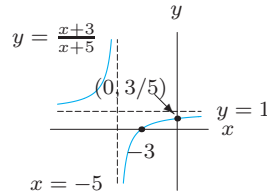
5 x-int: $x = \pm 2$
y-int: None
Horiz asy: $y = 0$
Vert asy: $x = 0, x = -4$

7 x-int: $x = 2$
y-int: $y = 1/2$
Horiz asy: $y = 1$
Vert asy: $x = 4$

9 (c) Horizontal: $y = 2$
Vertical: $x = -4$

$G(x) = \frac{2x}{x+4}$

11
$y = 2 + 1/x$
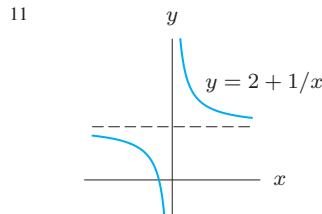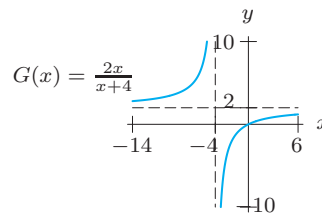
13 (a) $-\infty$
(b) $+\infty$

15 (a) (iii)
(b) (i)
(c) (ii)
(d) (iv)
(e) (vi)
(f) (v)

17 (a) 0, 0
(b) $\lim_{x \to -2^+} f(x) = \infty$;
$\lim_{x \to -2^-} f(x) = \infty$

19 (a) Small
(b) Large
(c) Undefined
(d) Positive
(e) Negative

21 (a)
$y = 4$
$(-3, 2)$ $(0, 0)$ $(1, 2)$

(b)
$x = -1$ $x = 3$
$y = -\frac{1}{2}$
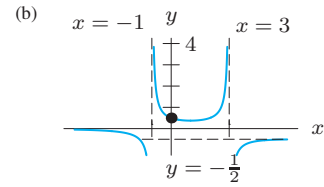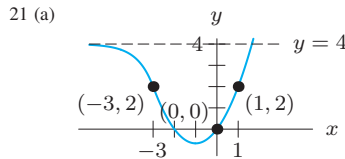
23 (a) $y = -1/(x + 2)$
(b) $y = -1/(x + 2)$
(c) $(0, -1/2)$

25 $p = 1, (0, 11/3), (11/4, 0)$
$x = 3, y = 4$

$x = 3$
$y = 4$
$(0, \frac{11}{3})$
$(\frac{11}{4}, 0)$

27 $p = 1, (0, 3), (3/2, 0)$
$x = 1, y = 2$

$x = 1$
$y = 2$
$(0, 3)$
$(\frac{3}{2}, 0)$
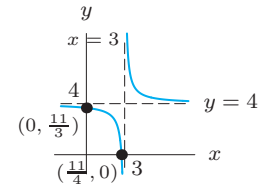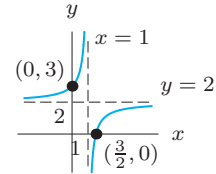
29 (a) $y = 1/x$
(b) $y = x/(2x - 4)$

31 (a) $1/x$
(b) $y = (1/x) + 2$

33 $y = -(x + 1)/(x - 2)$

35 $y = -(x - 3)(x + 2)/((x + 1)(x - 2))$

37 $y = (x - 2)/((x + 1)(x - 1))$

39 $y = x - 9; (2, -7)$

41 $h(x) = (x^4 - 2x^3)/(x - 2)$

43 $g(x) = (x - 5)/((x + 2)(x - 3))$

Section 11.6

1 $p(x) = 25^x$

3 Neither

5 $r(x) = 2(\frac{1}{9})^x$

7 A - (i)
B - (iv)
C - (ii)
D - (iii)

11 $y = 6x^{35}$

13 $y = 50x^{1.1}$

15 $y = e^{-x}$

17 (a) $f(x) = 720x - 702$
(b) $f(x) = 2(9)^x$
(c) $f(x) = 18x^4$

19 (a) $f(x) = y = \frac{63}{4}x + \frac{33}{2}$
(b) $f(x) = 3 \cdot 4^x$
(c) $f(x) = \frac{3}{4}x^6$

21 $A: kx^{5/7}; B: kx^{9/16};$
$C: kx^{3/8}; D: kx^{3/11}$

23 $m = 2, t = 4, k = \frac{1}{4}$

25 $y \to 0$ as $x \to \pm\infty$

27 $y \to 0$ as $t \to \infty$
$y \to 7/9$ as $t \to -\infty$

29 $y \to \infty$ as $x \to \infty$
$y \to -\infty$ as $x \to -\infty$

31 $y \to 0$ as $x \to \infty$

33 $y \to \infty$ as $x \to \infty$
$y \to -\infty$ as $x \to -\infty$

35 $y \to \infty$ as $x \to \infty$
$y \to 0$ as $x \to -\infty$

37 $f(x) = 2\sin(\frac{\pi}{2}x) + 4$ (trigonometric);
$g(x) = -\frac{5}{2}x^3$ (power function);
$h(x) = \frac{1}{3}(\frac{1}{2})^x$ (exponential)

39 (a) $p_5(r) = 1000[(1 + r)^5 + (1 + r)^4 +$
$(1 + r)^3 + (1 + r)^2 + (1 + r) + 1];$
$p_{10}(r) = 1000[(1 + r)^{10} + (1 + r)^9 +$
$(1 + r)^8 + (1 + r)^7 + (1 + r)^6 + (1 +$
$r)^5 + (1 + r)^4$
$+ (1 + r)^3 + (1 + r)^2 + (1 + r) + 1]$
(b) 20.279%

Section 11.7

1 $f(x) = x^{\ln c / \ln 2}$

3 $g(x) = 2x^{1.2}$

5 (a) $f(x) = 201.353x^{2.111}$
(b) $f(20) = 112{,}313.62$ gm
(c) $x = 18.930$ cm

7 $y = x^{3/2}$

9 $y = (3/2)x$

11 $y = e^{0.4x}$

13 (a) $y = -83.039 + 61.514x$; superb fit
(b) Good only for close values
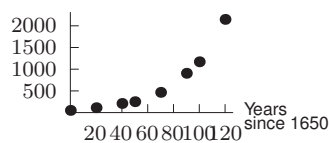
15 $a \approx 3.49$

17 (b) $R(p) =$
$-0.0565p^2 + 72.9981p + 4749.85$
(c) $p = \$646, R = \$28,349$

19 (a) $C(t) = 841.368(1.333)^t$
(b) 33.3% per year
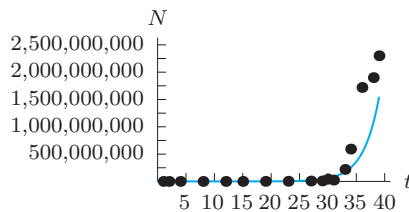(c) Slower growth; concave down

21 (a)

Population (thousands)

(b) $P(t) = 56.108(1.031)^t$, answers may vary
(c) 56.108 is 1650 population, 1.031 means 3.1% annual growth
(d) $P(100) = 1194.308$, slightly higher
(e) $P(150) = 5510.118$, higher

23 (a) $N = 1148.55e^{0.3617t}$

(b) About 1.92 years

25 (a) $y = 0.310t^2 - 12.177t + 144.517$
(b) $y = 3.01t^2 - 348.43t + 10{,}955.75$
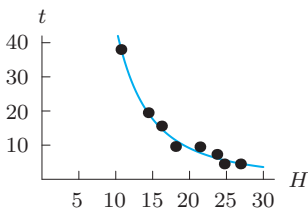
27 (b) Points lie on a line

29 (a) Quadratic
(b) $y = -34.136x^2 + 3497.733x - 39{,}949.714$; answers may vary
(c) $\$42,734$; answers may vary
(d) Age 10, $-\$8386$, not reasonable; answers may vary

31 (a) $t = 8966.1H^{-2.3}$

(b) $r = 0.0124H - 0.1248$
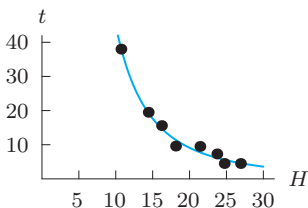
(c) $H = 0°C; H = 10.1°C$; model (b)

33 Yes; $k \approx 0.2; P = 0.2D^{3/2}$

Chapter 11 Review

1 Yes; $k = 1/6$ and $p = -7$

3 No

5 No

7 Yes; $y = x^2$

9 Even

11 Odd

13 Odd

15 $k = 2\sqrt[3]{7}, p = 11/15$

17 4th degree

19 $y \to \infty$; like $4x^4$

21 $y \to \infty$; like $2x^9$

23 $x = (3 \pm \sqrt{33})/4$

25 Not rational

27 $y = 4/e^{-x}$

29 (a) 2
(b) 5/6

31 Not a power function

33 Graph (i): J;
Graph (ii): L;
Graph (iii): O;
Graph (iv): H

35 $y = -\frac{3}{2}(x + 4)(x + 2)(x - 2)$

37 $y = \frac{1}{2}(x + \frac{1}{2})(x - 3)(x - 4)$

39 $y = -x(x + 3)(x - 2)$

41 $y = (x + 3)x^2$

43 $y = (x + 3)(x + 2)(x + 1) + 4$

45 (a) $y = 1/(x - 2)^2 - 1$
(b) $y = (-x^2 + 4x - 3)/(x^2 - 4x + 4)$
(c) $(0, -3/4), (1, 0)$ and $(3, 0)$

47 (a) $y = -1/(x - 3)^2$
(b) $y = -1/(x^2 - 6x + 9)$
(c) $(0, -1/9)$

49 (a) $-2, -3$; None
(b) $-2, -3$; No; $r(x) \to 1$ as $x \to \pm\infty$
(c) No; Yes at $x = -2$ and $x = 3$;
$s(x) \to 1$ as $x \to \pm\infty$

51 (a) False
(b) False
(c) True
(d) False

53 $f(x) = (x + 3)(x - 2)/((x + 5)(x - 7))$

55 $f(x) = (x + 1)/(x - 1)$

57 $f(x) = (-1/5)(x + 3)(x - 2)(x - 5)$

59 $h(x) = (1/5)(x + 5)(x + 1)(x - 4) + 7$

61 $d = 0.1x$; 32.5 miles

63 (a) 20 lbs; 1620 lbs
(b) 3/10

65 (a) 500 people
(b) May of 1908
(c) 790; February of 1907

67 (b) $k \approx 0.0087$
(c) Yes

69 (c)

Ch. 11 Understanding

1 False
3 True
5 True
7 False
9 True
11 True
13 False
15 True
17 False
19 False
21 True
23 False
25 True
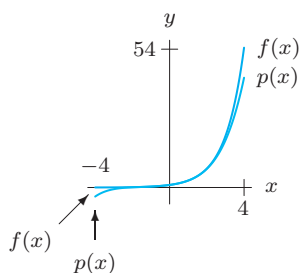27 True
29 True
31 True
33 True
35 False
37 False
39 True
41 True
43 False
45 False
47 False

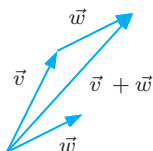## Ch. 11 Skills: Fractions

1 $41/35$
3 $(3 - 4x)/6x$
5 $-2(1 - 2y)/yz$
7 $(2 - 3x)/x^2$
9 $1/18$
11 $x/2$
13 $(4y^3z - 3wx)/(x^2y^4)$
15 $(8(y + 4))/(y - 4)$
17 $(-27x + 44)/((x + 1)(3x - 4))$
19 $(x + 20)/(x^2 - 16)$
21 $1/2r$
23 $(x - 1)/(\sqrt{x})^3 = x\sqrt{x} - \sqrt{x}/x^2$
25 $(4x + 1)/(b - a)$
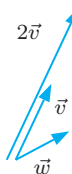27 $(r_2r_3 + r_1r_3 + r_1r_2)/(r_1r_2r_3)$
29 $(2a + 3)/((a + 3)(a - 3))$

31 $(-2x - h)/\left(x^2(x + h)^2\right)$
33 $-2x - h$
35 $1 - (1/a)$
37 $x^2y/(2x + 1)$
39 $(2x - 4x^4)/(x^3 + 1)^3$
41 $13/x^2 + 1/(2x^3)$
43 $(2/l^2) + (1/l^3) - 4/(3l^4)$
45 $1/6 - 1/(4x)$
47 $1 - 7/(x + 5)$
49 $1 + 1/R$
51 $1 + \sin x/\cos x$
53 False
55 False
57 True

Section 12.1

1 Scalar
3 Vector
5 Scalar
7 Vector
9

11

13
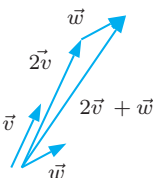
15 $\vec{p} = 2\vec{w}$
$\vec{q} = -\vec{u}$
$\vec{r} = \vec{u} + \vec{w}$
$\vec{s} = 2\vec{w} - \vec{u}$
$\vec{t} = \vec{u} - \vec{w}$
17 (a) 1.710 miles
(b) 5.848 miles
19 5.116 miles; 14.639° east of north
21 14,705 meters;
angle of 17.819° from horizontal
23 (a) 14.3373
(b) Veers right
(c) Not possible

Section 12.2

1 $-3\vec{i} - 4\vec{j}$
3 $\vec{w} \approx -0.725\vec{i} - 0.95\vec{j}$
5 $\vec{i} + 3\vec{j}$
7 $0.3\vec{i} - 1.8\vec{j} + 0.03\vec{k}$
9 $\sqrt{11} \approx 3.317$
11 7.649
13 $-5\vec{i} + 10\vec{j}$ knots
15 45° or $\pi/4$
17 90° or $\pi/2$
19 $-140.847\vec{i} + 140.847\vec{j} + 18\vec{k}$
21 $21\vec{j} + 35\vec{k}$
23 (a) 50 km/hr
(b) Horizontal: 43.301; vertical: 25
25 (a) $3.536(\vec{i} + \vec{j})$.
(b) $3.536\vec{i} + 4.736\vec{j}$
27 (a) (i) $\vec{m} = 3\vec{j}, \vec{h} = 2\vec{j}$

(i)

(ii) $\vec{m} = 3\vec{j}, \vec{h} = 2\vec{i}$

(ii)

(iii) $\vec{m} = 3\vec{j}, \vec{h} = \vec{i} + \sqrt{3}\vec{j}$

(iii)

(iv) $\vec{m} = -3\vec{j}, \vec{h} = \sqrt{2}\vec{i} + \sqrt{2}\vec{j}$

(iv)

(b) $3\vec{j} - 2\vec{i}$

(c) $\sqrt{2}\vec{i} + (\sqrt{2} - 3)\vec{j}$

$$\vec{h} = \sqrt{2}\vec{i} + \sqrt{2}\vec{j}$$

$\vec{S}$

$\vec{m} = -3\vec{i}$
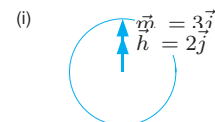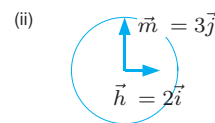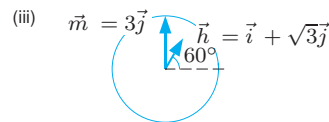
29 $\vec{k}$

31 $\vec{i} + \vec{k}$

Section 12.3

1 $(2, 2, 4, 6, 10, 16)$

3 $(-4, -5, -5, -5, -4, -2)$

5 $(5, 6, 7, 8, 9, 10)$

7 $(13/6, 5/2, 10/3, 25/6, 11/2, 22/3)$

9 $(3.63, 1.44, 6.52, 1.43, 1.20, 0.74)$

11 $(3.467, 1.277, 6.357, 1.267, 1.037, 0.577)$

13 $(79.000, 79.333, 89.000, 68.333, 89.333)$

15 $3.378°$ north of east

17 (a) $\vec{v} = 4.330\vec{i} + 2.500\vec{j}$
For the second leg of his journey, $\vec{w} = x\vec{i}$

$\vec{w}$ finish

$\vec{v}$ $10°$

start $30°$
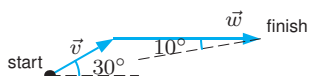
(b) $x = 9.848$
(c) 14.397

19 (a) $\vec{F}_{net} = (8, 7)$
(b) $\vec{F}_4 = (-8, -7)$

21 $\vec{q}_a = 1.065\vec{i} + 1.966\vec{j}$; $(1.065, 1.966)$
$\vec{q}_b = 2.703\vec{i} + 3.113\vec{j}$; $(2.703, 3.113)$
$\vec{q}_c = 2.129\vec{i} + 3.933\vec{j}$; $(2.129, 3.933)$
$\vec{q}_d = 0.491\vec{i} + 2.785\vec{j}$; $(0.491, 2.785)$

Section 12.4

1 -7

3 -38

5 14

7 -2

9 $28\vec{j} + 14\vec{k}$

11 238

13 $108.435°$

15 2100 ft-lbs

17 1.911 radians $(109.471°)$

19 For both, max $= 11$, min $= 3$

21 No

25 (a) $\vec{a} = (3, 2, 4)$; $\vec{c} = (c_b, c_e, c_m)$
$3c_b + c_e + 4c_m = 40$, or $\vec{a} \cdot \vec{c} = 40$
(c) The "freshness-adjusted" cost is cheaper at Beta

27 $43.297°$

29 (a) Width
(b) Height
(c) Perimeter

Section 12.5

1 (a) $\begin{pmatrix} 15 & 35 \\ 10 & -5 \end{pmatrix}$

(b) $\begin{pmatrix} -2 & 10 \\ 0 & -16 \end{pmatrix}$

(c) $\begin{pmatrix} 4 & 2 \\ 2 & 7 \end{pmatrix}$

(d) $\begin{pmatrix} -8 & -26 \\ -6 & 11 \end{pmatrix}$

(e) $\begin{pmatrix} 13 & 45 \\ 10 & -21 \end{pmatrix}$

(f) $\begin{pmatrix} k & -5k \\ 0 & 8k \end{pmatrix}$

3 (a) $\begin{pmatrix} 12 & 8 & 20 & 4 \\ 16 & 24 & 28 & 12 \\ 4 & 36 & 20 & 32 \\ 0 & -8 & 16 & 24 \end{pmatrix}$

(b) $\begin{pmatrix} -2 & -12 & -8 & -4 \\ -6 & -10 & 2 & -14 \\ -18 & -8 & -14 & -6 \\ -4 & -16 & -8 & -10 \end{pmatrix}$

(c) $\begin{pmatrix} 2 & -4 & 1 & -1 \\ 1 & 1 & 8 & -4 \\ -8 & 5 & -2 & 5 \\ -2 & -10 & 0 & 1 \end{pmatrix}$

(d) $\begin{pmatrix} 6 & -12 & 3 & -3 \\ 3 & 3 & 24 & -12 \\ -24 & 15 & -6 & 15 \\ -6 & -30 & 0 & 3 \end{pmatrix}$

(e) $\begin{pmatrix} 4 & 8 & 9 & 3 \\ 7 & 11 & 6 & 10 \\ 10 & 13 & 12 & 11 \\ 2 & 6 & 8 & 11 \end{pmatrix}$

(f) $\begin{pmatrix} 10 & -4 & 12 & 0 \\ 10 & 14 & 30 & -2 \\ -14 & 28 & 6 & 26 \\ -4 & -24 & 8 & 14 \end{pmatrix}$

5 (a) $(51, 15, 38)$
(b) $(-8, -11, 33)$
(c) $(70, 20, 22)$
(d) $(11, -6, 17)$
(e) 681
(f) $\begin{pmatrix} 24 & 60 & 84 \\ 48 & -72 & 36 \\ 192 & -60 & 0 \end{pmatrix}$

7 (a) Defined
(b) Not defined
(c) Not defined
(d) Not defined
(e) Defined
(f) Not defined

9 (a) $\mathbf{T} = \begin{pmatrix} 0.90 & 0 & 0 \\ 0.10 & 0.50 & 0.02 \\ 0 & 0.50 & 0.98 \end{pmatrix}$

(b) $\vec{p_1} = (1.8, 0.2, 0)$,
$\vec{p_2} = (1.62, 0.28, 0.1)$,
$\vec{p_3} = (1.458, 0.304, 0.238)$

11 (a) $\mathbf{T} = \begin{pmatrix} 0.97 & 0.05 \\ 0.03 & 0.95 \end{pmatrix}$

(b) $\vec{p}_{2006} = (214, 386)$,
$\vec{p}_{2007} = (226.88, 373.12)$.

13 (a) $\vec{v} = \begin{pmatrix} 11 \\ 19 \end{pmatrix}$

(b) $\vec{v} = \begin{pmatrix} 5 \\ 11 \end{pmatrix}$

(c) $\vec{v} = \begin{pmatrix} 2a + b \\ 3a + 2b \end{pmatrix}$

15 (a) $\lambda_2 = -1$
(b) $\lambda_3 = -1$
(c) $\mathbf{A}\vec{v} = \lambda\vec{v}$, and $\mathbf{A}\vec{v}$ is parallel to $\vec{v}$

17 (a) $\begin{pmatrix} 3 & 5 \\ 2 & 4 \end{pmatrix} \begin{pmatrix} a \\ b \end{pmatrix} = a \begin{pmatrix} 3 \\ 2 \end{pmatrix} + b \begin{pmatrix} 5 \\ 4 \end{pmatrix}$

(b) $\vec{v} = \begin{pmatrix} -8.5 \\ 5.5 \end{pmatrix}$

(c) $\vec{v} = -8.5\vec{c_1} + 5.5\vec{c_2}$

Chapter 12 Review

1 $(3, 3, 6)$

3 $(-3, -2, 9)$

5 $(7, 8, -21)$

7 $(4, -2, 18)$

9 $-4.5\vec{i} + 8\vec{j} + 0.5\vec{k}$

11 13

13 6

15 $6\vec{i} + 6\vec{j} + 6\vec{k}$

17 $\vec{a} = \vec{b} = \vec{c} = 3\vec{k}$
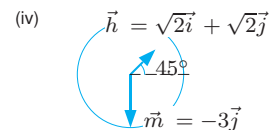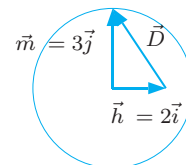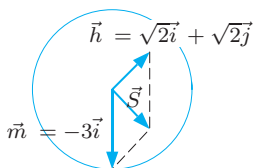$\vec{d} = 2\vec{i} + 3\vec{k}$
$\vec{e} = \vec{j}$
$\vec{f} = -2\vec{i}$

19 $\|\vec{u}\| = \sqrt{6}$
$\|\vec{v}\| = \sqrt{5}$

21 (a) Yes
(b) No

23 (a) $\vec{L} = (11, 7, 11, 7, 13)$
(b) $\vec{F} = (32, 36, 21, 8, 4)$,
$\vec{G} = (3, 3, 2, 0, 7)$

25 $F = g \sin \theta$

29 $0.4v\vec{i} + 0.693v\vec{j}$

31 (a) $\overrightarrow{AB} = 2\vec{i} - 2\vec{j} - 7\vec{k}$
$\overrightarrow{AC} = -2\vec{i} + 2\vec{j} - 7\vec{k}$
(b) $\theta = 44.003°$

35 $\overrightarrow{AB} = -\vec{u}$; $\overrightarrow{BC} = 3\vec{v}$;
$\overrightarrow{AC} = \overrightarrow{AB} + \overrightarrow{BC} = -\vec{u} + 3\vec{v}$; $\overrightarrow{AD} = 3\vec{v}$

37 $3\vec{n} - 3\vec{m}$;
   $3\vec{m} + \vec{n}$;
   $4\vec{m} - \vec{n}$;
   $\vec{m} - 2\vec{n}$

Ch. 12 Understanding

1 False

3 False

5 False

7 False

9 True

11 True

13 False

15 True

17 True

19 False

21 True

23 False

25 True

Section 13.1

1 Not arithmetic

3 Arithmetic

5 Arithmetic, $a_n = 3 + 3n$

7 Arithmetic, $a_n = -0.9 - 0.1n$

9 Not geometric

11 Geometric

13 Not geometric

15 Geometric; $4(1/2)^{n-1}$

17 Geometric; $1/(1.2)^{n-1}$

19 $1, 5/4, 7/5, 3/2$; not geometric

21 $-1, 1, -1, 1$; geometric

23 $1, 1/\sqrt{2}, 1/\sqrt{3}, 1/2$; not geometric

25 $n \geq 101$

27 $10.8, 64.8, 4.8 + 1.2n$

29 $7.9, 57.4, 2.4 + 1.1n$

31 $1.661, 7(0.75)^{n-1}$

33 $486, 2 \cdot 3^{n-1}$

35 (a) 646.7, 650.580, 654.484, 658.411
  (b) 367.7, 396.748, 428.091, 461.911
  (c) 2012

37 (a) 17.960, 18.314, 18.675
  (b) $17.960(1.0197)^n$
  (c) 36.5 years

39 Arithmetic, $d > 0$

41 Arithmetic, $d < 0$

43 $2, 7, 12, 17; a_n = -3 + 5n$

45 $3, 7, 15, 31$;
  $a_n = 2^{n-1} \cdot 3 + 2^{n-2} + 2^{n-3} + \cdots + 1$

47 (a) 150, 187.5, 199.219, 199.997, 200,
    200; converging

49 (a) $256
  (b) $d_n = 4^n$

Section 13.2

1 Not arithmetic

3 Not arithmetic

5 $(-1)^2 + 0^2 + 1^2 + 2^2 + 3^2 + 4^2 + 5^2$

7 $1 + 3 + 5 + 7 + 9 + 11$

9 $(-1)^2 + (-1)^3 + (-1)^4 + \cdots + (-1)^{10}$

11 $\sum_{n=1}^{7} 3n$

13 $\sum_{n=1}^{8} (1/2)n$

15 (a) $\sum_{i=1}^{10} 2i$
  (b) 110

17 $a_1 = 3, d = 4$

19 $a_1 = 2, d = 9$

21 500,500

23 2625

25 -132

27 -561

29 -111.3

31 150; 2325

33 (a)   (i) 226.6, 248.7, 281.4; population at census time
     (ii) 28.6, 22.1, 32.7; change in population over the decade.
     (iii) 3.27; average yearly population growth over the decade.

35 612

37 9

39 (a) 256 feet, 400 feet, 576 feet
  (b) 744 feet, 600 feet, 424 feet

41 7.906 sec

43 Last row: 106
  Auditorium: 1360

45 (a) 297

Section 13.3

1 1,572,768

3 5.997

5 781.248

7 7.199

9 Yes, $a = 1$, ratio $= -1/2$

11 Yes, $a = 5$, ratio $= -2$

13 $\sum_{n=1}^{6} (-1)^{n+1}(3^n)$

15 $\sum_{n=0}^{5} (-1)^n 32(\frac{1}{2})^n$

17 189/32

19 1 if N is even and 0 is N is odd.

21 (a) $\sum_{n=1}^{25} 81(1.012)^{n-1}$
  (b) 2345.291 bn barrels

23 (a) \$64,735.69
  (b) \$65,358.46

25 (a) Doubles
  (b) Less than doubles
  (c) More than doubles

27 (a) \$59,159.48
  (b) \$5927.45

Section 13.4

1 Yes, $a = 1$, ratio $= -x$

3 No. Ratio between successive terms is not constant

5 Yes, $a = e^x$, ratio $= e^x$

7 Yes, $a = 1$, ratio $= \sqrt{2}$

9 $1/(1 + x), |x| < 1$

11 10

13 1/54

15 4

17 $x^2/(1 - x^2)$

19 235/999

21 11/90

23 3781/4950

25 (a) $P_n = 250(0.04) + 250(0.04)^2 + \cdots + 250(0.04)^{n-1}$
  (b) $P_n = 10(1 - (0.04)^{n-1})/(1 - 0.04)$
  (c) $P_n = 10.417$

27 22.3 million dollars

29 \$1081.11

Chapter 13 Review

1 603; 59

3 (a) $1 + 5 + 9 + 13 + 17$
  (b) 45

5 No

7 $1/(1 - 2z), |z| < 1/2$

9 315

11 $n(n + 1)/2$

13 24 cans at bottom
  3 less per row
  8 rows

15 435

17 \$25,503.33

19 (a) 300, 350, 400, 450, 500, 550, 600.
  (b) 950 yards
  (c) 31st day and after

21 (a) $h_n = 10(3/4)^n$
  (b) $D_1 = 10$ feet
    $D_2 = h_0 + 2h_1 = 25$ feet
    $D_3 = h_0 + 2h_1 + 2h_2 = 36.25$ feet
    $D_4 = h_0 + 2h_1 + 2h_2 + 2h_3 \approx 44.688$ feet
  (c) $D_n = 10 + 60\left(1 - (3/4)^{n-1}\right)$
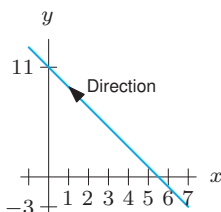
23 (a) \$1250
  (b) 12.50

Ch. 13 Understanding

1 True

3 True

5 True

7 True

9 True

11 False

13 True

15 False

17 False

19 False
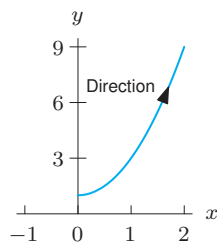
21 True

23 False

25 False

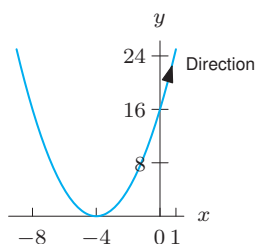27 True

29 False

31 False

33 False

Section 14.1

1 $x = 1 + 2t, y = 3 + t, 0 \le t \le 1$

3 $x = t, y = t, 0 \le t \le 1, x = t, y = 2 - t$, for $1 \le t \le 2$.
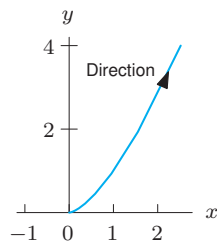
5 True

7 False

9 $y = 11 - 2x$
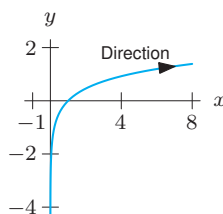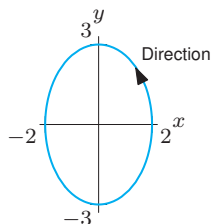

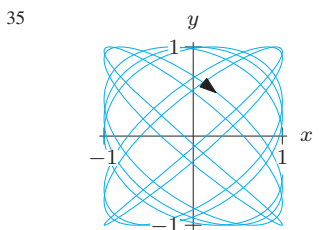11 $y = 2x^2 + 1$

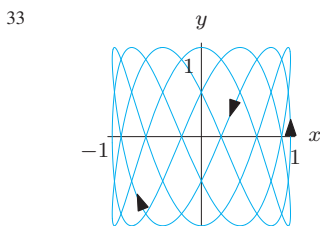13 $y = (x + 4)^2$

15 $y = x^{3/2}$

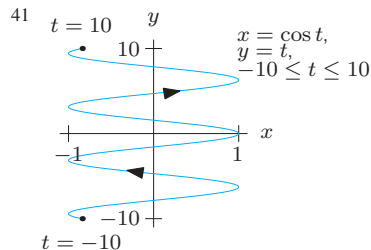17 $y = (2/3) \ln x, x > 0$

19 $(x^2/4) + (y^2/9) = 1$

21 Lines from $(0, 0)$ to $(2, 0)$ to $(2, 1)$ to $(0, 1)$ to $(0, 0)$

23 Lines from $(2, 0)$ to $(1.5, 1)$ to $(0.5, -1)$ to $(0, 0)$ to $(0.5, 1)$ to $(1.5, -1)$ to $(2, 0)$

25 Clockwise for all t.

27 Clockwise: $t < 0$,
Counter-clockwise: $t > 0$.

31 (a) $x = t, y = t^2$
$x = t + 1, y = (t + 1)^2$
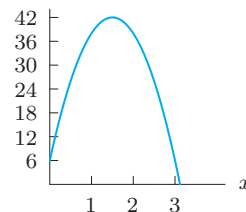(b) $x = t, y = (t + 2)^2 + 1$
$x = t + 1, y = (t + 3)^2 + 1$

33

35

37 (a) Line $y = x$
(b) Circle, with starting point $(1, 0)$ and period 2π
(c) Ellipse, with starting point $(1, 0)$ and period 2π

39 $x = t, y = -4t + 7$

41

43 (a) $x = t, y = -16t^2 + 48t + 6$
(b)

(c) 6 feet
(d) 3 seconds
(e) 42 feet

Section 14.2

1 Explicit

3 Implicit

5 Implicit

7 $(0, 0) ; \sqrt{10/3}$

9 $(4, 4) ; 2$

11 $x = 4 \cos t, y = -4 \sin t, 0 \le t \le 2\pi$

13 $x = 5 \sin t, y = -5 \cos t, 0 \le t \le 2\pi$

15 $x = 3 + 5 \cos t, y = 4 + 5 \sin t, 0 \le t \le 2\pi$

17 $x = -2 - \sqrt{5} \sin t, y = 1 + \sqrt{5} \cos t$, $0 \le t \le 2\pi$

19 True

21 (a) Center $(2, -4)$, radius $\sqrt{20}$
(b) Center $(-1, 2)$, radius $\sqrt{11}$

23 Parabola:
$y = (x - 2)^2, 1 \le x \le 3$

25 $x = 4(y - 3)^2, 2 \le y \le 4$.

27 Implicit: $xy = 1, x > 0$
Explicit: $y = 1/x, x > 0$
Parametric: $x = t, y = 1/t, t > 0$

29 Explicit: $y = \sqrt{4 - x^2}$
Implicit: $y^2 = 4 - x^2$ or $x^2 + y^2 = 4, y > 0$
Parametric: $x = 4 \cos t, y = 4 \sin t$, with $0 \le t \le \pi$
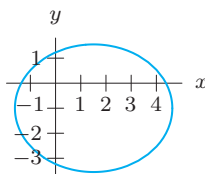
31 (a) $x = t, y = 1$
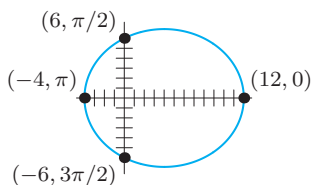(b) $x = t + \cos t, y = 1 - \sin t$
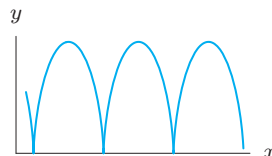
Section 14.3

1 (a) $(0,0)$; 4; $2\sqrt{5}$
  (b) $(x^2/4) + (y^2/5) = 1$
3 (a) $(1,0)$; 16; 12
  (b) $((x-1)^2/64) + y^2/36 = 1$
5 $x = -2\cos t, y = -5\sin t, 0 \le t \le 2\pi$
7 $x = 1 + 8\cos t, y = -6\sin t, 0 \le t \le 2\pi$
9 Same ellipse; traced opposite direction
11 (a) Center $(-1,3)$, major axis $a = \sqrt{6}$, minor axis $b = 2$
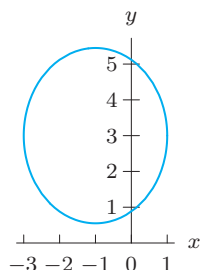
  (b) Center $(3/2, -1)$, major axis $a = \sqrt{39}/2$, minor axis $b = \sqrt{13/2}$

13 $((x-1)^2/4) + (y+2)^2 = 1$; $(1,-2)$; 2; 1
15 $(x+2)^2 + (y+1)^2/4 = 1$; $(-2,1)$; 1; 2
17 $((x+1/2)^2/4) + ((y-1/2)^2/9) = 1$; $(-\frac{1}{2}, \frac{1}{2})$; 2; 3
19 $0 < k < b < h < a$
21 (b) Min $= r_0/(1+\epsilon)$
      Max $= r_0/(1-\epsilon)$
 (c) Center $= (8,0)$

  (d) $2r_0/(1-\epsilon^2)$
23 (a) $\left(\dfrac{2x - r_m + r_e}{r_e + r_m}\right)^2 + \dfrac{y^2}{b^2} = 1$
  (b) $b = \sqrt{r_e r_m}$

Section 14.4

1 (a) $(0,7)$; $(0,-7)$; $(0,0)$
  (b) $y = 7x/2$; $y = -7x/2$
  (c) $(y^2/49) - (x^2/4) = 1$
3 (a) $(4,4)$; $(2,4)$; $(3,4)$
  (b) $y = 3x - 5$; $y = -3x + 13$
  (c) $(x-3)^2 - (y-4)^2/9 = 1$
5 $x = 2\tan t, y = 7/\cos t$;
  Upper half: $0 \le t < \pi/2, 3\pi/2 < t < 2\pi$
7 $x = 3 + 1/\cos t, y = 4 + 3\tan t$;
  Left half: $\pi/2 < t < 3\pi/2$
9 $((x-1)^2/4) - (y-2)^2 = 1$
  $(1,2)$; right-left; 2; 1
11 $((x+1)^2/4) - (y+3)^2 = 1$
  $(-1,-3)$; right-left; 2; 1
13 $(y-1/2)^2 - ((x-1)^2/9) = 1$
  $(1, 1/2)$; up-down; 3; 1
15 II; $k < h < 0 < a < b$.
17 (a) Center $(-5, 2)$; Vertices $(-5 \pm \sqrt{6}, 2)$; Asymptotes $y = \pm(2/\sqrt{6})(x+5) + 2$
  (b) Center $(-1, -2)$; Vertices $(-1 \pm \sqrt{14}, -2)$; Asymptotes $y = \pm(x+1) - 2$

Section 14.5

1 Ellipse; x-axis
3 Hyperbola; y-axis
5 Hyperbola; y-axis
7 $(0, \pm\sqrt{5})$
9 $(0, -2)$, vertical axis
11 (a), (b), (c)
13 $(\pm\sqrt{2}, 0)$
15 $x = -(1/4)y^2$
17 The mess sergeant's
19 $(-2,0)$; $(-31/16, 0)$
21 $x = (1/8)y^2 + 1$; $x = -1$
23 $(0,0)$; $(0,0)$
25 $(-2,3)$; $(-2 \pm 5/\sqrt{2}, 3)$
27 $x^2/3 + (y-2)^2/4 = 1$
29 $(\pm 2\sqrt{2}, 0)$; $(\pm\sqrt{24}, 0)$
31 $y^2/49 - x^2/4 = 1$; $(0, \pm\sqrt{53})$
33 Back to original focal point
35 No
37 9 inches
39 3 ft above center
41 (a) 5338 million km
  (b) $(x - 2581)^2/2669^2 + y^2/680^2 = 1$
  (c) $x = 2581 + 2669\cos t$,
      $y = 680\sin t, 0 \le t \le 2\pi$
43 (a) $(y-4)^2/0.486 - x^2/0.514 = 1$
  (b) $(y - 2.5)^2/0.844 - x^2/5.406 = 1$
  (c) $y = -0.697\sqrt{1 + x^2/0.514} + 4$;
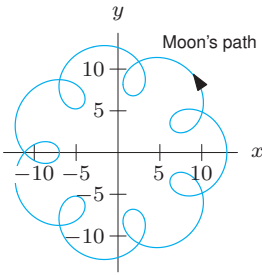 $y = -0.919\sqrt{1 + x^2/5.406} + 2.5$

(d)
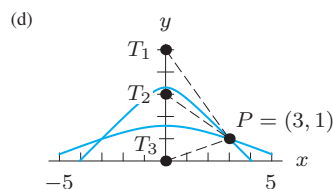
Section 14.6

1 $x = \sinh t, y = \cosh t, -\infty < t < \infty$
3 $x = -\cosh t, y = \sinh t, -\infty < t < \infty$
5 $x = 1 + 2\sinh t, y = -1 - 3\cosh t$, $-\infty < t < \infty$
7 $x = -1 + (\sinh t)/2, y = -3 - (\cosh t)/3$, $-\infty < t < \infty$
9 $x = -1 + 3\sinh t, y = -3 + 2\cosh t$, $-\infty < t < \infty$
13 $\sinh x \to (e^x)/2$ as $x \to \infty$
   $\sinh x \to -(e^{-x})/2$ as $x \to -\infty$
15 $x = -1 - 2\cosh t, y = 1 + \sinh t, -\infty < t < \infty$
17 $x = 3 + 2\sinh t, y = -\frac{1}{2} + \sqrt{2}\cosh t$, $-\infty < t < \infty$
19 $x = h + a\cosh t$ and $y = k + b\sinh t$
21 Yes, $\cosh 2x = \cosh^2 x + \sinh^2 x$
25 $\sin(ix) = i\sinh x$

Chapter 14 Review

1 Circle; $(0,3)$; $\sqrt{5}$
3 Hyperbola, $(0,1)$; 2; 3; left-right
5 Ellipse, $(5,0)$; 2; 3
7 Hyperbola, $(-1/3, 1/2)$; $\sqrt{3}$; $\sqrt{2}$; up-down
9 $x = 3\cos t, y = -3\sin t, 0 \le t \le 2\pi$
11 $x = -2\cos t, y = 2\sin t$, $0 \le t \le 2\pi$
13 $x = 5\cos t, y = 7\sin t$, $0 \le t \le 2\pi$
15 $x = -3\cos t, y = -7\sin t$, $0 \le t \le 2\pi$
17 $(\pm\sqrt{21}, 0)$
19 $(0, 1/20)$; $y = -1/20$
21 $x = \cos t, y = \sin t$
23 Circle; $(-1, 0)$; 1
25 Ellipse; $(1, -\frac{1}{3})$; 1; $\sqrt{2/3}$
27 No, since $(0,1)$ not on curve
29 (a) $x = 10\cos t, y = 10\sin t$
  (b) $x = 10\cos t + 3\cos 8t$
      $y = 10\sin t + 3\sin 8t$

(c)

Moon's path

Ch. 14 Understanding

1 True
3 True
5 False
7 False
9 False
11 True
13 False
15 True
17 True
19 True
21 False
23 False
25 True
27 False
29 False
31 True
33 False