Review Exercise 1.9

A

1. Given $h = \{(-4, 5), (-3, 6), (0, 8), (1, 7), (2, 9)\}$.
   (*a*) Why is h a function?
   (*b*) State the domain of h.
   (*c*) State the range of h.
   (*d*) What is the image of -3 under h?
   (*e*) Find $h(-4)$, $h(0)$, and $h(2)$.
   (*f*) If $h(x) = 7$, find x.

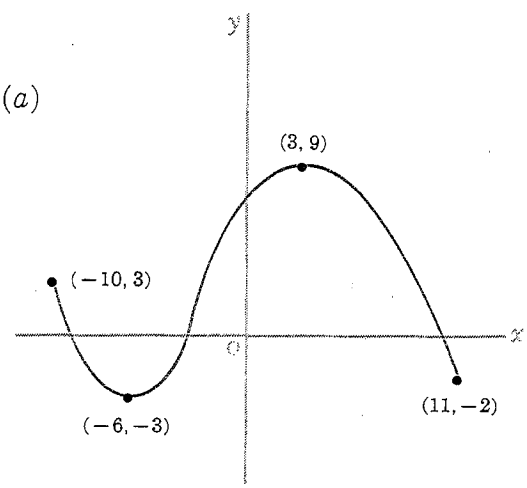
2. Given $g = \{(x, y) \mid y = 2x - 5\}$.
   (*a*) Why is g a function?
   (*b*) State the domain and range of g.
   (*c*) Give a defining equation of g.
   (*d*) Find $g(-1)$, $g(0)$, and $g(3)$.
   (*e*) If $g(x) = 3$, find x.

3. Given $f : x \to \sqrt{49 - x^2}$.
   (*a*) Why is f a function?
   (*b*) Find the domain of f.
   (*c*) Find the range of f.
   (*d*) Find $f(0)$, $f(1)$, $f(3)$, and $f(5)$.

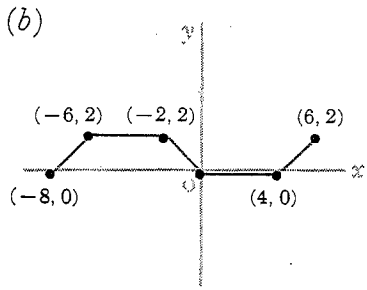
4. Given $f = \{(x, y) \mid y \text{ is a car owned by } x\}$
   and $g = \{(x, y) \mid y \text{ is the only car owned by } x\}$.
   Which is a function? Explain.

5. From the graph of the function in each of the following, state the intervals over which the function may be increasing, decreasing, or constant.

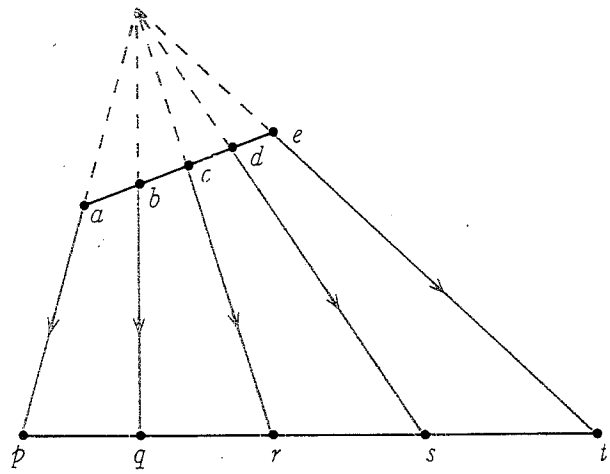
(*a*)



(*b*)



6. The mapping f is illustrated in the diagram.



(a) List f as a set of ordered pairs of points.
(b) Find $f(a)$, $f(c)$, $f(d)$, and $f(e)$.
(c) Find $f^{-1}(q)$, $f^{-1}(s)$, and $f^{-1}(t)$.
(d) Find $f^{-1}(f(a))$, $f^{-1}(f(c))$, and $f^{-1}(f(e))$.
(e) List three elements of $f^{-1} \circ f$.

7. Given $f = \{(3, 5), (6, 2), (-4, 0), (4, 10), (12, -4)\}$.
(a) List $2f$ and $3f$.
(b) List $-f$ and $-2f$.

8. Given $h = \{(0, 8), (-2, 3), (-5, 9), (4, 7), (9, 11)\}$ and $k = \{(0, -8), (-5, 6), (9, -9)\}$.
(a) State the domain of h, k, $h + k$, and $h - k$.
(b) List $h + k$.
(c) List $h + h$.
(d) List $k + k$.
(e) List $k + h$.
(f) List $h - k$.
(g) List $k - h$.

In a group of cows and chickens, the number of legs was 84 more than twice the number of heads. How many cows were there?

9. Given $f = \{(x, y) \mid y = \sin x\}$ and $g = \{(x, y) \mid y = x\}$.
State defining equations of $f + g$, $f - g$, and $g - f$.

10. Given $f = \{(-2, 6), (0, 6), (1, 31), (2, 0)\}$ and $k = \{(-4, 1), (-2, 1), (0, 4), (1, 0)\}$.
(a) State the domain of $f \cdot k$.
(b) List $f \cdot k$.
(c) List $k \cdot k$.

11. Given $f : x \to 2x^2$ and $g : x \to \frac{x}{5}$.

(*a*) State a defining equation of $f \cdot g$.

(*b*) State defining equations of $\frac{f}{g}$ and $\frac{g}{f}$.

(*c*) State the domain of $f \cdot g$.

(*d*) State the domain of $\frac{f}{g}$.

(*e*) Why are the domains of $f \cdot g$ and $\frac{f}{g}$ different?

12. Given $f = \{(1, 6), (2, 5), (3, 4), (4, 7)\}$
and $g = \{(4, 1), (5, 3), (6, 2), (8, 5)\}$.

(*a*) Find $(g \circ f)(3)$.
(*b*) Find $(g \circ f)(1)$.
(*c*) Find $(f \circ g)(6)$.
(*d*) Does $(f \circ g)(8)$ exist? Explain.
(*e*) Find the domain and range of $f \circ g$ and $g \circ f$.

13. Given $f = \{(1, 4), (2, 6), (3, 5), (5, 2)\}$.

(*a*) List the inverse of f.
(*b*) Is f^{-1} a function? Explain.

14. Given $f = \{(1, 4), (2, 6), (3, 5)\}$
and $g = \{(5, 2), (3, 7), (4, 5), (2, 1)\}$.

(*a*) List f^{-1} and g^{-1}.
(*b*) List $f \circ g$.
(*c*) List $(f \circ g)^{-1}$.
(*d*) List $g^{-1} \circ f^{-1}$.
(*e*) How are $(f \circ g)^{-1}$ and $g^{-1} \circ f^{-1}$ related?

15. Which of the following functions are 1 : 1?

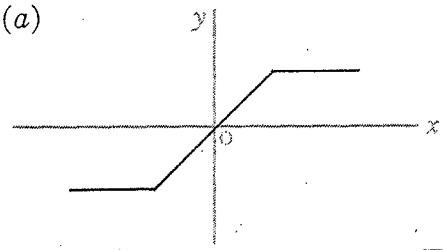
(*a*) $f : x \to 2x + 7$
(*b*) $g : x \to |x + 1|$
(*c*) $h : x \to 3x^2$
(*d*) $h : x \to \sqrt{x}$

16. Given $f(x) = 2x - 3$.

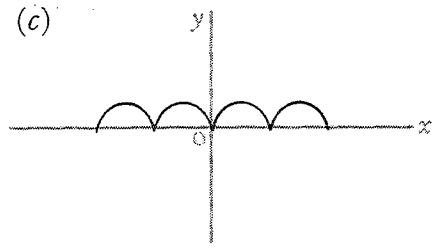
(*a*) Find $f(a + 2)$
(*b*) Find $f(x^2)$
(*c*) Find $f(x^2 - 2)$
(*d*) Find $f\left(x + \frac{3}{2}\right)$
(*e*) Find $f(x^2 + 2x)$
(*f*) Find $f\left(\frac{1}{x}\right)$

17. Which of the following may be graphs of even functions? Of odd functions? Of neither odd nor even functions?

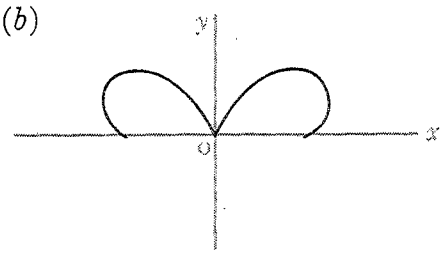
(a)



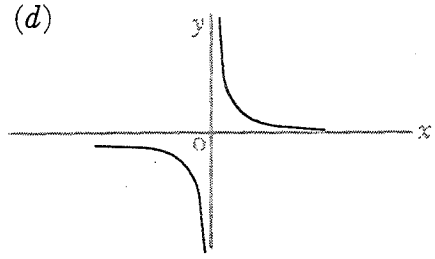
(c)



(b)



(d)



B 18. For each of the following, find the largest domain of x for which f is a real-valued function.

(a) $f(x) = \sqrt{x - 4}$
(b) $f(x) = \sqrt{9 - x^2}$
(c) $f(x) = \dfrac{1}{1 - x}$
(d) $f(x) = \dfrac{1}{x^2 - 9}$

18. (b) $x^2 < 9$
$\Leftrightarrow$
$-3 < x < 3$

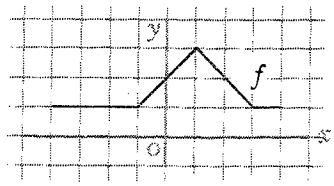
19. Given $f : x \to x^2 + 3x$.

(a) Find $f(0), f(1), f(-1), f(3), f(-3)$.
(b) What is the image of 5 under f?
(c) If $(4, y) \in f$, find y.
(d) If $(x, 10) \in f$, find x.

20. For each of the following functions find $f(a)$, $f(-a)$, and $-f(-a)$. Determine whether the function is even, odd, or neither odd nor even.

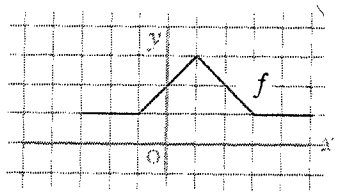
(a) $f = \{(x, y) \mid y = 2\}$
(b) $f = \{(x, y) \mid y = |x|\}$
(c) $f = \left\{(x, y) \mid y = \dfrac{1}{x}\right\}$
(d) $f : x \to x^2 - 2$
(e) $f : x \to x^2 + 2x$
(f) $f : x \to (x - 4)^2$

21. Given the graph of a function, f. Draw the graphs of $3f$ and $-2f$ on the same axes.

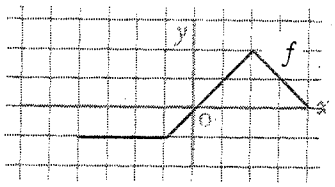


22. Given $f = \{(x, y) \mid y = 2x^3 - 5x + 7\}$, find the defining equation of each of the following functions.
(a) $3f$ (b) $-2f$ (c) $-f$

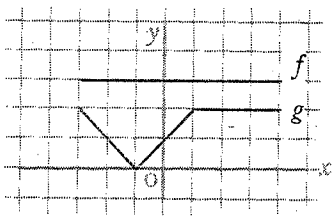
23. Given the graph of f. Draw the graph of $\{(x, y) \mid y = f(x) - 2\}$.



24. Given the graph of f. Draw $\{(x, y) \mid y = |f(x)|\}$.



25. Given the graphs of f and g, graph $f + g$.



26. Use the graph of Question 25 and graph each of the following.
(a) $f - g$
(b) $g - f$
(c) $2f + g$
(d) $2f + 3g$
(e) $2f - g$
(f) $2f - 3g$

27. Given $f = \{(x, y) \mid y = 3x - 4\}$ and
$g = \{(x, y) \mid y = x^2\}$.
(a) Find the domain of f and g.
(b) Find a defining equation of $f + g$.
(c) Graph f, g, and $f + g$.

28. (a) Graph $f : x \to x^3$.
(b) Graph $g : x \to -4x$.
(c) Graph $f + g$.
(d) Find a defining equation of $f + g$.

29. Given the semicircle $f : x \to \sqrt{25 - x^2}$ and the line $\ell : x \to 2x$.
   (*a*) Graph f and ℓ.
   (*b*) Find the domain of f, ℓ, and $f + \ell$.
   (*c*) Graph $k = f + \ell$.
   (*d*) Find a defining equation of $f + \ell$.
   (*e*) Graph $h = -(f + \ell)$.
   (*f*) Describe the graph of the relation $k \cup h$.
   (*g*) Is the relation $k \cup h$ a function?

30. (*a*) Graph $f : x \to x^2 - 4$.
   (*b*) Graph $g : x \to x$.
   (*c*) Graph $f \circ g$.
   (*d*) Find a defining equation of $f \circ g$.

31. Graph $k : x \to \dfrac{1}{3 - x}$ and find equations of the vertical and horizontal asymptotes.

32. Given $f : x \to \dfrac{1}{x}$, $g : x \to x^2 - 9$.
   (*a*) Find a defining equation of $f \circ g$.
   (*b*) Graph $f \circ g$.
   (*c*) Find equations of the vertical asymptotes of the graph of $f \circ g$.
   (*d*) Where is the graph of $f \circ g$ discontinuous?

33. For each of the following express $(f \circ g)(x)$ and $(g \circ f)(x)$ as polynomials.
   (*a*) $f : x \to 3x$, $\quad g : x \to x^2$
   (*b*) $f : x \to x + 3$, $\quad g : x \to 5x^2$
   (*c*) $f : x \to x + 5$, $\quad g : x \to (x - 5)$
   (*d*) $f : x \to 2x - 3$, $\quad g : x \to (x - 3)^2$

34. Given the *identity function* $i : x \to x$.
   Prove $i \circ f = f \circ i = f$.

35. Prove that the composition of two linear functions is a linear function.

36. For each of the following 1 : 1 functions, find a defining equation of the inverse of the function.
   (*a*) $f = \{(x, y) \mid y = 3x + 4\}$
   (*b*) $g = \left\{(x, y) \mid y = \dfrac{2x - 5}{3}\right\}$
   (*c*) $h = \{(x, y) \mid y = \sqrt{4 - x}\}$

37. If $f(x) = 3x - 4$ and $g(x) = 4x + 5$, prove that $(f \circ g)^{-1} = g^{-1} \circ f^{-1}$.

38. Suppose the graph of f is given. Describe by transformations how the graph of the functions defined in each of the following may be obtained from the graph of $y = f(x)$.

(a) $y = f(x) + 5$

(b) $y = f(x) - 7$

(c) $y = f(x + 2)$

(d) $y = f(x - 3)$

(e) $y = -f(x)$

(f) $y = 2f(x)$

(g) $y = \frac{1}{3} f(x)$

(h) $y = f(3x)$

(i) $y = f\left(\frac{x}{2}\right)$

(j) $y = f(-2x)$

(k) $y = f\left(-\frac{x}{5}\right)$

(l) $y = f(x - 3) + 4$

(m) $y = f(x + 5) - 2$

(n) $y = f^{-1}(x)$

(o) $y = 2f(x - 3)$

(p) $y = 3f(x - 2) + 5$

39. Compare the graph of each of the following with the graph of $y = \sin x$.

(a) $f : x \to 3 + \sin x$

(b) $g : x \to \sin (x + 2)$

(c) $h : x \to \sin (x - 3)$

(d) $f : x \to \sin 2x$

(e) $f : x \to \sin (2x + 5)$

(f) $g : x \to \sin (3x - 5)$

(g) $h : x \to \sin \left(\frac{2x - 3}{5}\right)$

C 40. Prove that the composition of a linear and a quadratic function is a quadratic function.

41. (a) Graph $y = x - \text{gif}\, x$ for $0 \leq x \leq 4$.

(b) For $p(x) = x - \text{gif}\, x$, show that $p(x + 1) = p(x)$.

(c) Describe the graph of $p(x)$.

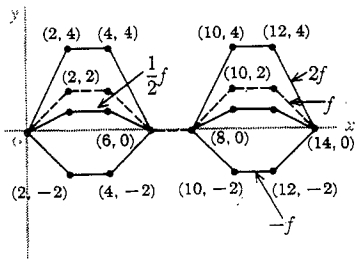
42. (a) Graph $y = \text{sgn}\, (p(x) - \frac{1}{2})$ for $0 \leq x \leq 4$, where $p(x) = x - \text{gif}\, x$.

(b) For $q(x) = \text{sgn}\, (p(x) - \frac{1}{2})$, show that $q(x) + 1) = q(x)$.

(c) Describe the graph of $q(x)$.

Exercise 1.8, Page 56

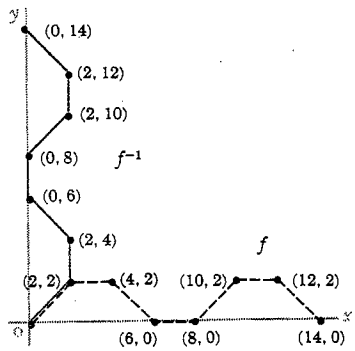
1. (*a*) (*c*) (*e*)



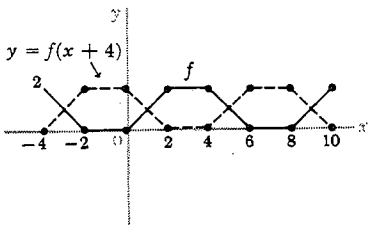
(*b*) stretch parallel to the y axis

(*d*) compressed to half size

(*g*)



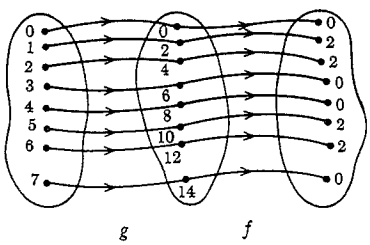
(*i*)



2. (*b*) The graph of $f \circ g$ is congruent to the graph of g but translated 5 units parallel to the y axis.

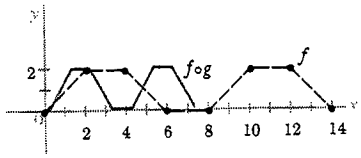
3. $(f \circ g)(x) = g(x) + a$

4. (*a*)



(*b*) $\{(0, 0), (1, 2), (2, 2), (3, 0), (4, 0), (5, 2), (6, 2), (7, 0)\}$

(*c*)



11. (*a*) $y = x^2 + 4$
(*b*) $y = x^2 - 5$
(*c*) $y = (x - 3)^2$
(*d*) $y = (x + 2)^2$
(*e*) $y = (x - 3)^2 + 4$
(*f*) $y = (x + 1)^2 + 3$
(*g*) $y = (x + 2)^2 - 2$
(*h*) $y = (x - 3)^2 - 1$
(*i*) $y = -x^2$
(*j*) $y = -x^2 + 4$
(*k*) $y = -(x + 1)^2$
(*l*) $y = -(x - 1)^2 + 5$

12. $g(x) = 2x$

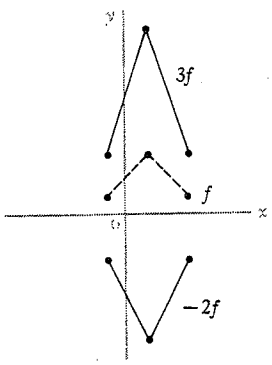
Exercise 1.9, Page 65

18. (*a*) $x \geq 4$ (*c*) $x \neq 1$
(*b*) $|x| \leq 3$ (*d*) $x \neq 3, -3$

19. (*a*) 0, 4, −2, 18, 0
(*b*) 40
(*c*) 28
(*d*) −5, 2

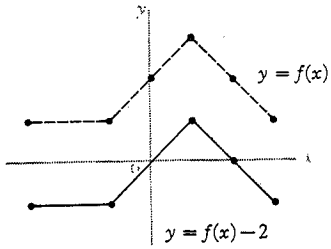
20. (*a*) even (*d*) even
(*b*) even (*e*) neither
(*c*) odd (*f*) neither

21.



22. (*a*) $3f = \{(x, y) \mid y = 6x^3 - 15x + 21\}$
(*b*) $-2f = \{(x, y) \mid y = -4x^3 + 10x - 14\}$
(*c*) $-f = \{(x, y) \mid y = -2x^3 + 5x - 7\}$

23.



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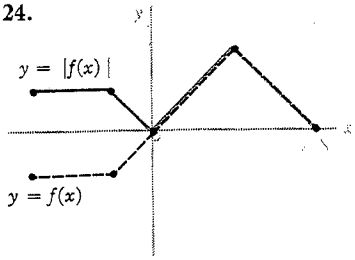
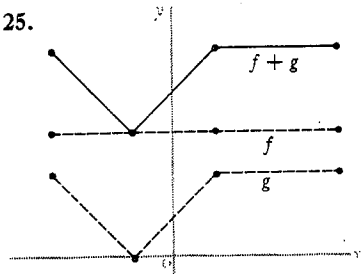
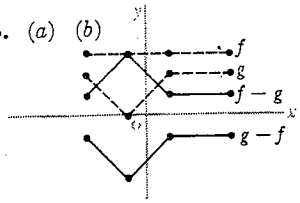


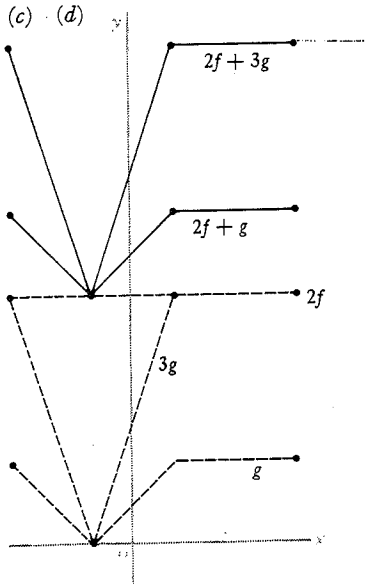
25.



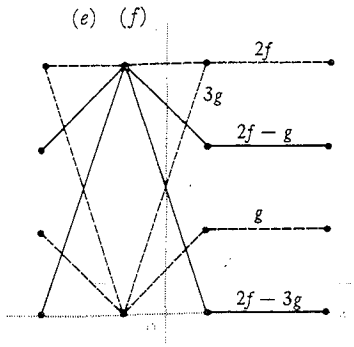
26. (*a*) (*b*)



(*c*) (*d*)

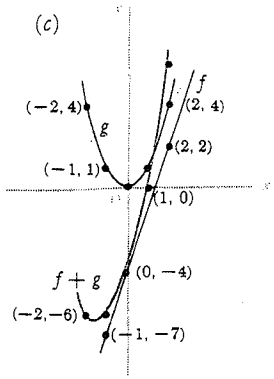


(e) (f)

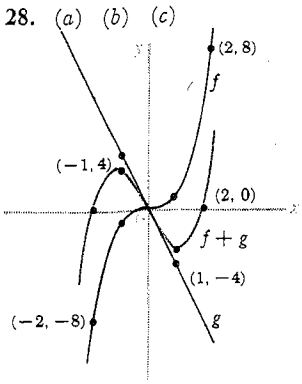


27. (a) $D_f = \{x \mid x \in R\}$
$D_g = \{x \mid x \in R\}$
(b) $y = x^2 + 3x - 4$

(c)

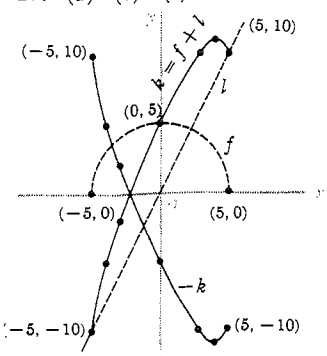


28. (a) (b) (c)



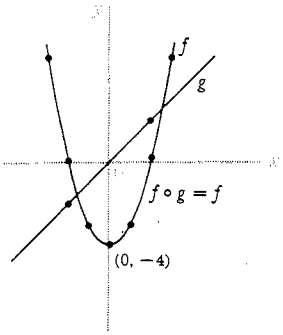
(d) $y = x^3 - 4x$

29. (a) (c) (e)



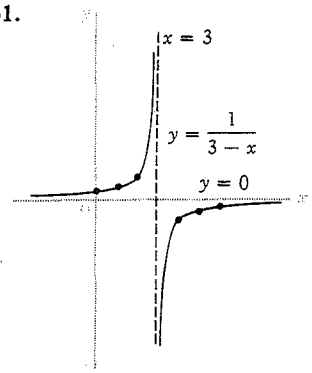
(b) $D_f = \{x \mid |x| \leq 5\}$
$D_l = \{x \mid x \in R\}$
$D_{f+l} = \{x \mid |x| \leq 5\}$
(d) $y = \sqrt{25 - x^2} + 2x$
(g) No

30. (a) (b) (c)



(d) $y = x^2 - 4$

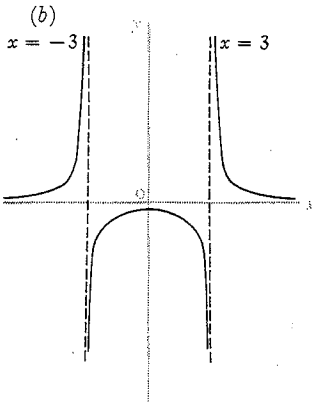
31.



vertical asymptote $x = 3$
horizontal asymptote $y = 0$

32. (a) $f \circ g = \left\{(x, y) \mid y = \dfrac{1}{x^2 - 9}\right\}$

(b)



(c) vertical asymptotes
$x = 3$, $x = -3$
horizontal asymptote
$y = 0$
(d) $x = 3$, $x = -3$

33. (a) $3x^2$, $9x^2$
(b) $5x^2 + 3$, $5(x + 3)^2$
(c) x, x
(d) $2(x - 3)^2 - 3$, $(2x - 6)^2$

36. (a) $y = \dfrac{x - 4}{3}$
(b) $y = \dfrac{3x + 5}{2}$
(c) $y = 4 - x^2$, $x \geq 0$

Chapter 2

Exercise 2.1, Page 76

1. All are parabolas, concave upward, passing through (0, 0).

2. All are parabolas, concave downward, passing through (0, 0).

4. (b) position of vertex stays the same
(i) $a > 0$ concave upward
(ii) $a < 0$ concave downward
(c) not affected

5. (a) parabola, concave upward
(b) $x = 0$
(c) (0, 1), (0, 2), (0, 0), (0, −1), (0, −2)
(d) $(x, y) \to (x, y + 2)$

6. (b) up, down
(c) (0, 3)

7. (a) $c = 0$
(b) $c < 0$
(c) $c > 0$

8. (a) $c = 0$
(b) $c > 0$
(c) $c < 0$

9. (a) 2000 N/m
(b) 9000 J, 6000 N
(c) 0.1 J, 20 N

10. (a) increased by a factor of 4
(b) 1.75×10^9
(c) 5×10^9

11. $y = \dfrac{a}{k}x^2$

Review Exercise 2.9

B

1. Which of the following define quadratic functions?

   (*a*) $x \to 4x^2 - 7,\ x \in R$ (*c*) $x \to x^3 - 7x + 3,\ x \in R$
   (*b*) $x \to (x - 3)^2,\ x \in R$ (*d*) $x \to 3x + 7,\ x \in R$

2. (*a*) Using the same axes, draw graphs for $|x| \leq 5$ of the functions defined by each of the following.
   $y = x^2,\quad y = 5x^2,\quad y = 10x^2,\quad y = -5x^2,\quad y = -10x^2$
   (*b*) Find the direction of opening of each parabola in (*a*).
   (*c*) Determine the domain and range of the function defined by each equation in (*a*).

3. (*a*) Using the same set of axes, draw graphs of the parabolas $y = 2x^2$ and $y = 2x^2 + 3$, where $x \in R$ and $|x| \leq 4$.
   (*b*) Find the axis of symmetry of each.
   (*c*) Find the coordinates of the vertex of each parabola.
   (*d*) Can the graph of the parabola $y = 2x^2$ be translated so that it coincides with that of $y = 2x^2 + 3$? If so, how?

4. (*a*) Draw graphs of the parabolas $y = \frac{1}{2}x^2$, $y = \frac{1}{2}x^2 + 3$ for the interval $|x| \leq 4$, and of the parabolas $y = \frac{1}{2}(x - 4)^2$, $y = \frac{1}{2}(x - 4)^2 + 3$ for the interval $0 \leq x \leq 8$. Use the same axes of coordinates.
   (*b*) Explain how each of the other graphs in (*a*) can be obtained as a translation of the graph of $y = \frac{1}{2}x^2$.

5. Find the coordinates of the maximum or minimum point for the parabola defined by each of the following.

   (*a*) $y = x^2 + 2$ (*d*) $y = 2(x + 3)^2 + 4$
   (*b*) $y = x^2 - 3$ (*e*) $y = -2(x - 5)^2 + 7$
   (*c*) $y = (x - 2)^2 + 5$ (*f*) $y = -\frac{1}{3}(x + 5)^2 - 9$

6. Find a translation and a reflection that map the parabola $y = 3x^2$ onto the parabola $y = -3(x - 4)^2 - 5$.

7. (*a*) For each parabola in Question 5, find an equation of a congruent parabola with vertex at the origin.
   (*b*) State the transformation that maps each parabola in 7 (*a*) onto the corresponding parabola of Question 5.

8. Express each of the following polynomials in the form $a(x-p)^2+q$.

(a) $2x^2-6x+9$
(b) x^2-5x+3
(c) $-3x^2+9x-7$
(d) $15+4x-2x^2$
(e) $3-7x+4x^2$
(f) $11-7x-3x^2$

9. (a) Express $3x^2-15x-18$ in the form $a(x-p)^2+q$, $x \in R$.
(b) Find the vertex of the parabola $y=3x^2-15x-18$. Is the vertex a maximum or minimum point? Explain.
(c) Find an equation of the axis of symmetry.

10. (a) Express $-2x^2+14x-12$ in the form $a(x-p)^2+q$.
(b) Find the vertex of the parabola $y=-2x^2+14x-12$. Is the vertex a maximum or minimum point? Explain.
(c) Find an equation of the axis of symmetry.

11. By completing a square, find the minimum value of the following.

(a) $y=x^2+4x+3$
(b) $y=3x^2-6x+7$
(c) $y=4x^2-8x+1$
(d) $y=x^2+4x+1$

12. Find the maximum or minimum value of the functions defined in each of the following.

(a) $y=4x-x^2$
(b) $y=12x+3x^2$
(c) $y=-6x-3x^2$
(d) $y=8x+6x^2$

Erik is twice as old as Neil used to be when Erik was as old as Neil is now. If Neil is now 18, how old is Erik?

13. If (a, b) is a point on the parabola $y=kx^2$ where $k \in R, k \neq 0$, show the following.

(a) The point $(a, -b)$ is on the parabola $y=-kx^2$.
(b) The point $(-a, b)$ is on the parabola $y=kx^2$.

14. The image of the point (x, y) in the origin is the point $(-x, -y)$. Find an equation of the curve with points that are images in the origin of the points of $y=4x^2$.

15. Sketch and shade the regions defined by each of the following.

(a) $y>x^2$
(b) $y<2-x^2$
(c) $y>x^2-x-12$
(d) $y>-x^2+7x-12$

C 16. A set of points or region is *convex* if every straight line segment, with end points belonging to the set, lies entirely in the set. Show that the set

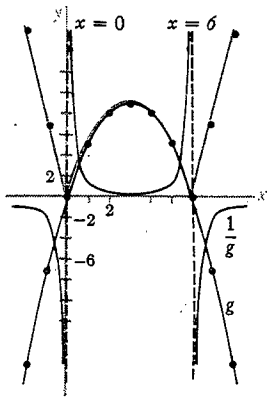
$$\{(x, y) \mid y>x^2, \quad x, y \in R\}$$

is convex. By finding a straight line segment that does not have this property, show that the set

$$\{(x, y) \mid y<x^2, \quad x, y \in R\}$$

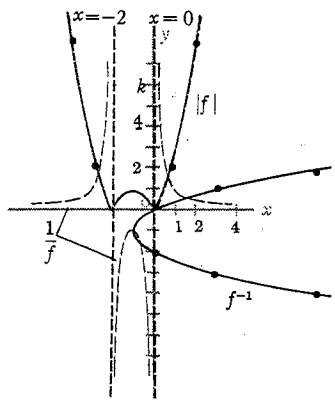
is *not* convex. Is a straight line convex?

2.



$\frac{1}{g}$ undefined for $x = 0, 6$

3.



4. 8 m

Exercise 2.9, Page 108

1. (*a*), (*b*)

2. (*b*) up, up, up, down, down
(*c*) domain $x \in R$; range for first three is $\{y \geq 0, y \in R\}$, range for last two is $\{y \leq 0, y \in R\}$

3. (*b*) $x = 0$
(*c*) $(0, 0)$, $(0, 3)$
(*d*) Yes, move the graph 3 units up along its axis of symmetry, thus, $(x, y) \to (x, y + 3)$

4. (*b*) $(x, y) \to (x, y + 3)$
$(x, y) \to (x + 4, y)$
$(x, y) \to (x + 4, y + 3)$

5. (*a*) $(0, 2)$ (*d*) $(-3, 4)$
(*b*) $(0, -3)$ (*e*) $(5, 7)$
(*c*) $(2, 5)$ (*f*) $(-5, -9)$

6. $(x, y) \to (x + 4, -(y - 5))$

7. (*a*) $y = x^2$, $y = 2x^2$
$y = x^2$, $y = -2x^2$
$y = x^2$, $y = -\frac{1}{3}x^2$
(*b*) $(x, y) \to (x, y + 2)$
$(x, y) \to (x, y - 3)$
$(x, y) \to (x + 2, y + 5)$
$(x, y) \to (x - 3, y + 4)$
$(x, y) \to (x + 5, y + 7)$
$(x, y) \to (x - 5, y - 9)$

8. (*a*) $2\left(x - \frac{3}{2}\right)^2 + \frac{9}{2}$
(*b*) $\left(x - \frac{5}{2}\right)^2 - \frac{13}{4}$
(*c*) $-3\left(x - \frac{3}{2}\right)^2 - \frac{1}{4}$
(*d*) $-2(x - 1)^2 + 17$
(*e*) $4\left(x - \frac{7}{8}\right)^2 - \frac{1}{16}$
(*f*) $-3\left(x + \frac{7}{6}\right)^2 + \frac{181}{12}$

9. (*a*) $3\left(x - \frac{5}{2}\right)^2 - \frac{147}{4}$
(*b*) $\left(\frac{5}{2}, -\frac{147}{4}\right)$, min.
(*c*) $x - \frac{5}{2} = 0$

10. (*a*) $-2\left(x - \frac{7}{2}\right)^2 + \frac{25}{2}$
(*b*) $\left(\frac{7}{2}, \frac{25}{2}\right)$, max.
(*c*) $x - \frac{7}{2} = 0$

11. (*a*) -1 (*c*) -3
(*b*) 4 (*d*) -3

12, (*a*) 4, max. (*c*) 3, max.
(*b*) -12, min. (*d*) $-\frac{8}{3}$, min.

14. $y = -4x^2$

15. (*a*) the interior region of a parabola concave upward with vertex $(0, 0)$
(*b*) the interior region of a parabola concave downward with vertex $(0, 2)$
(*c*) the interior region of a parabola concave upward with vertex $\left(\frac{1}{2}, -\frac{49}{4}\right)$
(*d*) the exterior region of a parabola concave downward with vertex $\left(\frac{7}{2}, \frac{1}{4}\right)$

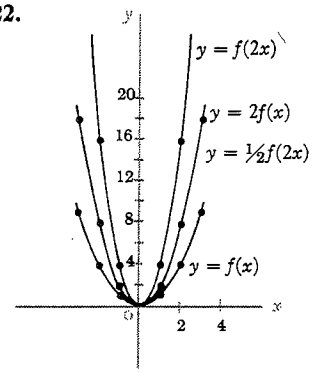
16. yes

17. 13.8 m, 3.2 s

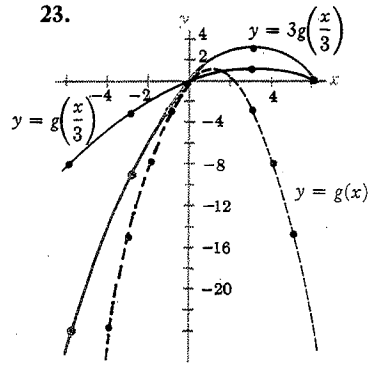
18. $t = \frac{4 + \sqrt{21}}{5}$ s, $x = \sqrt{21}$ m
$y = \frac{21 - x^2}{5}$

19. $y = -\frac{1}{5}(x - 2\sqrt{21})^2 + \frac{21}{5}$

22.



23.



24. (*a*) $f: x \to -\frac{x^2}{30} + 30$
(*b*) 90 cm

Chapter 3

Exercise 3.1, Page 120

3. (*a*) $\left\{-1, \frac{1}{2}\right\}$ (*f*) $\left\{\frac{2}{3}, 5\right\}$
(*b*) $\left\{-1, \frac{7}{8}\right\}$ (*g*) $\left\{-\frac{3}{4}, \frac{1}{3}\right\}$
(*c*) $\left\{-\frac{1}{3}, \frac{1}{3}\right\}$ (*h*) $\left\{0, \frac{5}{3}\right\}$
(*d*) $\{-2, 2\}$ (*i*) $\{0, -1, 1\}$
(*e*) $\{-8, 8\}$ (*j*) the roots are 0, 0, −1, 1

4.8 Summary of Chapter 4

Describe clearly the following concepts and terms.

division of a polynomial by a linear polynomial
division statement
Factor Theorem
zero of a polynomial
linear factor of a polynomial
solution of cubic and quartic equations
equations with related roots
sum and product of roots of $ax^2 + bx + c = 0$
$x^2 - Sx + P = 0$
graph of a cubic curve, degree 3
graph of a quartic curve, degree 4
tangent line to a curve at a point
slope of a tangent line

Review Exercise 4.8

B

1. Find the quotient and remainder in the following division problems.
   (*a*) Divide $x^3 + 5x^2 + 7x + 3$ by $x + 2$
   (*b*) Divide $x^3 - 9x + 4$ by $x - 3$
   (*c*) Divide $x^4 - 8x^3 + 5x^2 + 7x - 3$ by $x - 1$
   (*d*) Divide $x^3 + 6x^2 - 8x + 5$ by $2x + 1$

2. Write the division statement for each of the following problems.
   (*a*) Divide $-x^3 + 4x^2 - 6x + 3$ by $x + 1$
   (*b*) Divide $x^3 + 5x^2 - 9$ by $2x + 3$
   (*c*) Divide $x^4 + 18$ by $x + 2$

3. Without dividing, decide whether or not $x + 3$ is a factor of the following polynomials.
   (*a*) $x^3 + 3x^2 + 4x + 12$
   (*b*) $x^3 + 8x^2 + 8x - 16$
   (*c*) $x^4 + 4x^3 - 9x^2 - 6x + 4$
   (*d*) $x^4 - 81$

4. Find all the factors of the given polynomials.
   (*a*) $x^2 - 8x - 20$
   (*b*) $x^3 + 5x^2 - 7x + 1$
   (*c*) $x^3 - 3x^2 + 4x - 4$
   (*d*) $x^3 + x^2 - 11x + 4$
   (*e*) $x^3 + 5x^2 - 18x - 18$
   (*f*) $2x^3 + 13x^2 + 18x - 9$

5. Is $x - a$ a factor of the following polynomials?

(a) $x^p - a^p,\ p \in N$
(b) $x^8 + x^3a^5 - x^2a^6 - a^8$
(c) $x^{11} - 4a^7x^4 + 3a^{10}x$
(d) $x^4 + a^4$

6. Find the quotient when $x^3 - a^3$ is divided by $x - a$, and state the remainder.

7. Is $x + b$ a factor of the given polynomials? Explain.

(a) $x^4 + b^4$
(b) $x^5 + b^3x^2$
(c) $x^9 - 3b^2x^7 + 5bx^8 - b^9$
(d) $x^{12} - 10b^4x^8 - 6b^7x^5 + 5b^{10}x^2$

8. Is $x - \frac{1}{2}$ a factor of the following polynomials? Is $2x - 1$?

(a) $2x^3 - 4x^2 + 3x - 1$
(b) $4x^3 - 4x^2 + 5x - 2$

9. Find all the roots of the given equations by factoring, if $x \in C$.

(a) $x^3 - 3x^2 - 10x + 24 = 0$
(b) $x^3 - 3x^2 - 4x + 12 = 0$
(c) $x^3 - 5x^2 + 3x + 9 = 0$
(d) $x^3 + 10x^2 + 21x + 10 = 0$

10. State the sum and product of the roots of each of the following quadratic equations.

(a) $x^2 - 7x + 5 = 0$
(b) $2x^2 + 9x - 7 = 0$
(c) $3x^2 - 17x + 43 = 0$
(d) $-x^2 + 6x + 11 = 0$

11. Write a quadratic equation, the sum of whose roots is 19 and the product of roots 84.

12. For each of the following pairs of numbers state a quadratic equation having the numbers as roots.

(a) 1, 6
(b) 3, -4
(c) $2 + \sqrt{3}, 2 - \sqrt{3}$
(d) $1 + 4i, 1 - 4i$

13. One root of each of the following equations is 3. Find the unknown coefficient and the other root of each equation.

(a) $x^2 - 5x + k = 0$
(b) $4x^2 - 2x + k = 0$
(c) $2x^2 - kx + 6 = 0$
(d) $kx^2 - 8x - 3 = 0$

14. Find the polynomial having 3 and -4 as zeros that also takes the value 30 for $x = 1$.

SCARED SET
Unscramble the name of the soldier turned mathematician who therefore did not belong to this set.

15. Find the quadratic equation with roots related to the roots of $x^2 + 2x + 3 = 0$ as indicated in each of the following.

(*a*) The roots are twice as large.
(*b*) The roots are 4 greater.
(*c*) The roots are reciprocals of the given roots.
(*d*) The roots are squares of the given roots.

16. The roots of $x^2 + bx + 5 = 0$ are three times the roots of $x^2 + 2x + c = 0$. Find b and c.

17. The roots of $ax^2 + 3x + 7 = 0$ are reciprocals of the roots of $x^2 + bx + 2 = 0$. Find a and b.

18. Sketch graphs of the curves $y = f(x)$ defined by each of the following.

(*a*) $f(x) = x^3$
(*b*) $f(x) = x^3 + x^2$
(*c*) $f(x) = x^3 - 2x$
(*d*) $f(x) = x^4$
(*e*) $f(x) = x^4 - x^2$
(*f*) $f(x) = x^4 - 3x + 2$

19. (*a*) Sketch the graph of $y = x^3 - 2x$ for $|x| < 3$.
(*b*) Determine the points of intersection of the graph with the x axis.
(*c*) Describe the approximate location of any maximum or minimum points.

20. Sketch the graph of $y = 12x - x^3$ for $|x| < 4$. Determine the points of intersection with the x axis and describe the general nature of the curve. State the apparent location of the maximum and minimum points.

21. For $|x| \leq 3$ sketch graphs of the following, using addition of functions where appropriate.

(*a*) $y = x^3 - 4x^2 + 3x$
(*b*) $y = x^3 + 3x^2 + 2x$

22. Show that $x^4 + a^4 = (x^2 - \sqrt{2}ax + a^2)(x^2 + \sqrt{2}ax + a^2)$, and find all the roots of $x^4 + 16 = 0$.

23. Graph the given functions and note any maximum or minimum points. Plot in the interval $|x| \leq 4$.

(*a*) $f : x \to 3x^2 - 6x$
(*b*) $g : x \to 2x - 2x^2$
(*c*) $h : x \to x^3 - 3x^2$
(*d*) $k : x \to 12x - x^3$

4. (a) $x = 0, \dfrac{1+\sqrt{19}i}{2}, \dfrac{1-\sqrt{19}i}{2}$

(b) $x = 0, i\sqrt{3}, -i\sqrt{3}$

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

(d) $x = 0, 0, \dfrac{9}{2}$

(e) $x = 0, 4, -4$

(f) $x = i, -i, 3i, -3i$

5.

(a) x	y	(b) x	y
-4	272	-4	225
-3	90	-3	64
-2	20	-2	9
-1	2	-1	0
0	0	0	1
1	2	1	0
2	20	2	9
3	90	3	64
4	272	4	225

The real root is 0. The real roots are -1, 1.

(c) x	y	(d) x	y
-4	-55	-4	-68
-3	-20	-3	-30
-2	-3	-2	-10
-1	2	-1	-2
0	1	0	0
0.5	0.125	1	2
0.8	-0.09	2	10
1	0	3	30
2	5	4	68
3	22		
4	57		

The real roots are 1, -1.62, 0.62. 0 is the only real root.

(e) x	y	(f) x	y
-4	48	-4	306
-3	15	-3	110
-2	0	-2	30
-1	-3	-1	6
0	0	0	2
1	3	1	6
2	0	2	30
3	-15	3	110
4	-48	4	306

-2, 0, 2 are roots. No real roots.

6.

(a) x	y	(b) x	y
-1	-1	-1	-3
$-\frac{1}{2}$	$-\frac{1}{8}$	$-\frac{1}{2}$	$-\frac{1}{2}$
$-\frac{1}{4}$	$-\frac{1}{64}$	$-\frac{1}{4}$	$-\frac{3}{32}$
0	0	0	0
$\frac{1}{4}$	$\frac{1}{64}$	$\frac{1}{4}$	$-\frac{1}{32}$
$\frac{1}{2}$	$\frac{1}{8}$	$\frac{1}{2}$	0
1	1	1	1

(c) x	y	(d) x	y
-1	1	-1	0
$-\frac{1}{2}$	$\frac{1}{16}$	$-\frac{1}{2}$	$-\frac{7}{16}$
$-\frac{1}{4}$	$\frac{1}{256}$	$-\frac{1}{4}$	$-\frac{63}{256}$
0	0	0	0
$\frac{1}{4}$	$\frac{1}{256}$	$\frac{1}{4}$	$\frac{65}{256}$
$\frac{1}{2}$	$\frac{1}{16}$	$\frac{1}{2}$	$\frac{9}{16}$
1	1	1	2

7. $(x-1)(x-2)(x-3)(x-4)(x-5)(x-6) = 0$

8. No, since x^{20} is ≥ 0.

10. (c) $r_1 r_2 + r_2 r_3 + r_1 r_3 = \dfrac{c}{a}$

11. $x^3 - 9x^2 + 23x - 15 = 0$

12. $x^3 - 4x^2 + 14x - 20 = 0$

13. $x^4 - 6x^3 - 9x^2 + 94x - 120 = 0$

14. $x^4 - 9x^3 + 31x^2 - 9x - 50 = 0$

Exercise 4.7, Page 185

4. (a) $3x + 3$ (c) $-x - 1$
(b) $\frac{1}{2}x + \frac{1}{2}$ (d) $2x + 2$

5. (a) 6 (c) -2
(b) 1 (d) 4

6. (a) $2x + 2a$
(b) $-x - a$
(c) $x + a + 1$
(d) $4 - x - a$

7. (a) $4a$ (c) $2a + 1$
(b) $-2a$ (d) $4 - 2a$

8. (a) $8a$ (c) $2a + 3$
(b) $-4a$ (d) $60 - 32a$

9. $2at + b$

10. (a) $2x + 2$ (c) $-x + 4$
(b) $6x - 4$ (d) $8 - 2x$

Exercise 4.8, Page 186

1. (a) $x^2 + 3x + 1$, 1
(b) $x^2 + 3x$, 4
(c) $x^3 - 7x^2 - 2x + 5$, 2
(d) $\frac{1}{2}x^2 + \frac{11}{4}x - \frac{43}{8}, \frac{83}{8}$

2. (a) $-x^3 + 4x^2 - 6x + 3 = (x+1)(-x^2 + 5x - 11) + 14$
(b) $x^3 + 5x^2 - 9 = (2x+3)\left(\frac{1}{2}x^2 + \frac{7}{4}x - \frac{21}{8}\right) - \frac{9}{8}$
(c) $x^4 + 18 = (x+2)(x^3 - 2x^2 + 4x - 8) + 34$

3. (a) Yes (c) No
(b) No (d) Yes

4. (a) $(x-10)(x+2)$
(b) $(x-1)(x^2+6x-1)$
(c) $(x-2)(x^2-x+2)$
(d) $(x+4)(x^2-3x+1)$
(e) $(x-3)(x^2+8x+6)$
(f) $(x+3)(2x^2+7x-3)$

5. (a) Yes (c) Yes
(b) Yes (d) No

6. $x^2 + ax + a^2$, 0

7. (a) No (c) No
(b) Yes (d) No

8. (a) No, No
(b) Yes, Yes

9. (a) $\{-3, 2, 4\}$
(b) $\{-2, 2, 3\}$
(c) $\{-1, 3, 3\}$
(d) $\{-2, -4-\sqrt{11}, -4+\sqrt{11}\}$

10. (a) 7, 5
(b) $-\frac{9}{2}, -\frac{7}{2}$
(c) $\frac{17}{3}, \frac{43}{3}$
(d) 6, -11

11. $x^2 - 19x + 84 = 0$

12. (a) $x^2 - 7x + 6 = 0$
(b) $x^2 + x - 12 = 0$
(c) $x^2 - 4x + 1 = 0$
(d) $x^2 - 2x + 17 = 0$

13. (a) 6, 2
(b) $-30, -\frac{5}{2}$
(c) 8, 1
(d) 3, $-\frac{1}{3}$

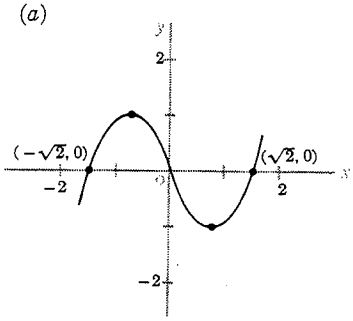
14. $-3x^2 - 3x + 36$

15. (*a*) $x^2 + 4x + 12 = 0$
(*b*) $x^2 - 6x + 11 = 0$
(*c*) $3x^2 + 2x + 1 = 0$
(*d*) $x^2 + 2x + 9 = 0$

16. $6, \frac{5}{9}$

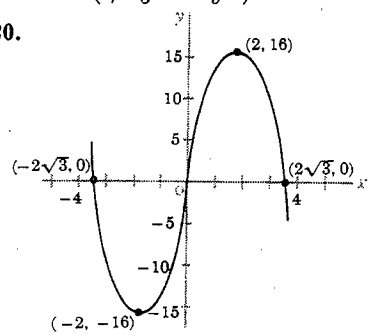
17. $14, \frac{3}{7}$

19. (*a*)



(*b*) $(0, 0)(\sqrt{2}, 0)(-\sqrt{2}, 0)$
(*c*) $\left(-\sqrt{\frac{2}{3}}, \frac{4\sqrt{6}}{9}\right)$, $\left(\sqrt{\frac{2}{3}}, -\frac{4\sqrt{6}}{9}\right)$

20.



Chapter 5

Exercise 5.1, Page 199

7. (*a*) 3 (*c*) 8
(*b*) 3 (*d*) 3^{a+3}

8. (*a*) $\{3\}$ (*e*) $\{2\}$
(*b*) $\{4\}$ (*f*) $\{5\}$
(*c*) $\{3\}$ (*g*) $\{1\}$
(*d*) $\{6\}$ (*h*) $\{3\}$

9. (*a*) $\frac{yz^2}{x^3}$ (*d*) 1
(*b*) 1 (*e*) 1
(*c*) 16 (*f*) a^{2x-2y}

10. (*a*) 16 (*d*) 5
(*b*) 27 (*e*) 81
(*c*) 4 (*f*) 2^n

12. (*a*) 2^{22} (*b*) 4^{4^4}

13. (*a*) x^{2a^2} (*c*) $\frac{2x^3}{5y^2}$
(*b*) 3^{6a} (*d*) $\frac{3a}{5b}$

14. (*a*) 125^3 (*b*) $(9^2)^3$

15. (*a*) 8 (*b*) 1 (*c*) 6

16. $\{x > 1\}$

Exercise 5.2, Page 204

5. (*a*) 1 (*f*) x^{-4}
(*b*) x^{-2} (*g*) z^5
(*c*) 3 (*h*) x
(*d*) 10^{-3} (*i*) x
(*e*) y^4

6. (*a*) $\frac{7}{2}$ (*c*) $\frac{3}{2}$ (*e*) $\frac{8}{15}$
(*b*) 2 (*d*) 4 (*f*) $\frac{19}{36}$

7. (*a*) $a^{-5}b^5$ (*d*) $x^{-4}y^5$
(*b*) x^3y^{-6} (*e*) $2a^{-4}b^2$
(*c*) $a^5b^{-7}c^3$ (*f*) $5x^6y^{-4}z^4$

8. (*a*) $\{6\}$ (*d*) $\{-3\}$
(*b*) $\{-7\}$ (*e*) I
(*c*) $\{-7\}$ (*f*) ϕ

9. (*a*) $\frac{(a+b)^2}{ab}$
(*b*) $\frac{ab}{a+b}$

10. (*a*) $\{-2\}$ (*b*) $\{2, -2\}$

Exercise 5.3, Page 206

1. (*a*) 2.4×10^{15}
(*b*) 1.8×10^{27}
(*c*) 1.6617×10^{-24}
(*d*) 1×10^{-8}
(*e*) 6.2×10^{-5}

2. (*a*) 7.34×10^8
(*b*) 5.7×10^{-8}
(*c*) 9.82×10^9
(*d*) 4.32×10^{-10}
(*e*) 7×10^{-6}
(*f*) 7.6×10^{-5}

3. (*a*) 4.5×10^3
(*b*) 4.5×10^{-1}
(*c*) 5.4×10^4
(*d*) 8.4×10^{-6}

4. (*a*) 57 600
(*b*) 0.0078
(*c*) 0.000 097
(*d*) 845 200 000
(*e*) 0.000 365
(*f*) 0.432

Exercise 5.4, Page 210

4. (*a*) $\frac{1}{27}$ (*f*) $\frac{1}{16}$
(*b*) $\frac{1}{36}$ (*g*) $\frac{1}{27}$
(*c*) $\frac{1}{16}$ (*h*) $\frac{1}{2}$
(*d*) $\frac{1}{4}$ (*i*) undefined
(*e*) $\frac{1}{3}$

5. (*a*) 3 (*c*) $\frac{1}{16}$
(*b*) $7^{\frac{7}{6}}$ (*d*) $\frac{8}{9}$

6. $\left\{2, \frac{3}{4}\right\}$

8. (*a*) $3^{\frac{1}{2}} > 4^{\frac{1}{3}}$
(*b*) $9^{\frac{3}{2}} > 25^{\frac{2}{3}}$
(*c*) $2^{-\frac{1}{3}} > 3^{-\frac{1}{2}}$
(*d*) $5^{-1} > 12^{-\frac{2}{3}}$

9. $\frac{a^{\frac{1}{3}}}{b^{\frac{1}{2}}}$

Exercise 5.7, Page 217

3. $\frac{1}{\sqrt[4]{2}}$

4. 11 600 a

5. \$1120

6. (*a*) 2, 2, 2
(*b*) 2 h
(*c*) 1

7. (*a*) 5, 5 (*d*) 9
(*b*) 5 d (*e*) $y = 2(2^{-\frac{t}{5}})$
(*c*) 5 d

8. $n = 6000 \times 3^5$
$n = 6000 \times 3^{\frac{x}{2}}$

9. 17 000 (*b*) 10

10. (*a*) 1 000 000 000 a
(*b*) 3 000 000 000 a

Review Exercise 5.8

A

1. For each of the following state the exponent and base.

(a) 5^3 (d) $(1.7)^{-2}$ (g) $(4.7)^{\pi}$

(b) $\left(\frac{1}{2}\right)^7$ (e) $\left(\frac{1}{1.5}\right)^{-5}$ (h) $(\cos 30°)^3$

(c) $(-3)^{\frac{1}{3}}$ (f) $(\pi)^{1.2}$ (i) $(\sec 40°)^2$

2. Multiply and express the product in exponential form.

(a) $3^2 \cdot 3^5$ (d) $5^4 \times 5^{-2}$ (g) $7^4 \cdot 7^{-4}$

(b) $(-2)^2(-2)^3$ (e) $3^7 \times 3^4 \times 3^{-6}$ (h) $x^{\frac{1}{2}} \cdot x^{-\frac{1}{2}}$

(c) $5 \cdot 5^2 \cdot 5^3$ (f) $\left(\frac{1}{2}\right)^0\left(\frac{1}{2}\right)^2\left(\frac{1}{2}\right)^3$ (i) $0^3 \cdot 0^4$

NOW TEN
Unscramble the name of this greatest of English mathematicians.

3. Divide and express the quotient in exponential form.

(a) $x^6 \div x^4$ (c) $x^5 \div x$ (e) $x^{n+1} \div x^n$

(b) $2^{12} \div 2^4$ (d) $x^{2n} \div x^n$ (f) $x^n \div x^n$

B

4. Evaluate.

(a) 2^{-4} (e) $16^{\frac{1}{2}}$ (i) $\left(2\frac{1}{4}\right)^{\frac{1}{2}}$

(b) $8^{\frac{2}{3}}$ (f) $25^{\frac{3}{2}}$ (j) $(2)^{-2}$

(c) $\left(\frac{1}{3}\right)^{-2}$ (g) $9^{-\frac{1}{2}}$ (k) $100^{1\frac{1}{2}}$

(d) $27^{\frac{1}{3}}$ (h) $(-8)^{\frac{1}{3}}$ (l) $\left(1\frac{9}{16}\right)^{-\frac{1}{2}}$

5. (a) Express 8^5 as a power of 2.
(b) Divide 8^6 by 2^{12} and simplify.

6. Express each of the following in standard form.

(a) 793 (c) 0.000 006 25

(b) 7050.6 (d) 9 820 000

(e) About 100 000 000 000 000 000 000 000 electrons are contained in a gram of matter.

(f) The energy of 90 000 000 000 000 000 J is locked up in one kilogram of matter.

7. Evaluate each of the following.

(a) $8^{\frac{2}{3}} - 5^0 + \left(\frac{4}{9}\right)^{-\frac{3}{2}}$ (d) $\dfrac{2^{-2} - (\frac{1}{2})^{-2}}{2^{-2}}$

(b) $\left(\frac{9}{4}\right)^{\frac{3}{2}} - 3^0 + 8^{-\frac{1}{3}}$ (e) $\dfrac{2^{-1}}{2^{-1} + 2^{-2}}$

(c) $12^0 - 4^{\frac{1}{2}} - \left(\frac{1}{27}\right)^{-\frac{2}{3}}$

8. Evaluate.

(a) $(2^{\frac{1}{2}} + 2^{-\frac{1}{2}})(2^{\frac{1}{2}} - 2^{-\frac{1}{2}})$ (b) $(2^{\frac{1}{2}} - 2^{-\frac{1}{2}})^2$

9. Find the value of each of the following.

(a) $(16^{-\frac{3}{4}})^0$

(b) $(0.1)^{-2}$

(c) $\sqrt[3]{125^{-1}}$

(d) $\left(\frac{81}{100}\right)^{-\frac{1}{2}}$

(e) $(0.001)^{\frac{2}{3}}$

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

(g) $\frac{1}{2^{-1} + 3^{-1}}$

(h) $32^{0.4}$

(i) $\frac{5^{-2} + 10^{-1}}{5^{-2}}$

(j) $\frac{5^{-3} \cdot 10^{-1}}{5^{-2}}$

10. Show that $3^{\frac{1}{2}} \cdot 3^{\frac{1}{2}} \cdot 3^{\frac{1}{2}} = 3^{\frac{1}{2}} + 3^{\frac{1}{2}} + 3^{\frac{1}{2}}$.

11. Solve.

(a) $2^x = 4$

(b) $3^x = \frac{1}{27}$

(c) $5^y = 625$

(d) $5^x = 0.2$

(e) $0.5^y = 0.125$

(f) $\left(\frac{2}{3}\right)^x = \frac{27}{8}$

(g) $8^x = 16$

(h) $32^x = 64$

(i) $9^x = 3^{12}$

12. On the same axes draw graphs of $y = 2^x$, $y = 4^x$, $y = 8^x$.

(a) How does the graph of $y = a^x$ change in the first quadrant as a increases?

(b) Where would the graph of $y = 3^x$ lie with respect to the original graphs? $y = 5^x$?

(c) How does the graph of $y = a^x$ change in the second quadrant as a increases?

13. For what values of x is each of the following true.

(a) $3^x = 1$

(b) $3^x > 1$

(c) $3^x < 1$

14. If the value of x is increased by 1, what is the increase in y if $y = 2^x$?

15. The half-life of radioactive lead is 27 min. What fraction of the radioactive lead remains after 13.5 min? After 108 min?

16. A colony of bacteria doubles its number every 4 h. Show that $n = n_0 2^{\frac{t}{4}}$. Find the number in the colony of bacteria 2 h after its population is 100 000.

11. (*a*) 1.5 d (*b*) 6.25%

12. 2400 a

13. (*a*) 0.5 d
(*b*) 12 500
(*c*) 5.15 d

Exercise 5.8, Page 220

4. (*a*) $\frac{1}{16}$ (*g*) $\frac{1}{3}$
(*b*) 4 (*h*) -2
(*c*) 9 (*i*) $\frac{3}{2}$
(*d*) 3 (*j*) $\frac{1}{4}$
(*e*) 4 (*k*) 1000
(*f*) 125 (*l*) $\frac{4}{5}$

5. (*a*) 2^{15}
(*b*) 64

6. (*a*) 7.93×10^2
(*b*) 7.0506×10^3
(*c*) 6.25×10^{-6}
(*d*) 9.82×10^6
(*e*) 1×10^{23}
(*f*) 9.0×10^{16} J

7. (*a*) $\frac{51}{8}$ (*d*) -15
(*b*) $\frac{23}{8}$ (*e*) $\frac{2}{3}$
(*c*) -10

8. (*a*) $\frac{3}{2}$ (*b*) $\frac{1}{2}$

9. (*a*) 1 (*f*) 6
(*b*) 100 (*g*) $\frac{6}{5}$
(*c*) $\frac{1}{5}$ (*h*) 4
(*d*) $\frac{10}{9}$ (*i*) $\frac{7}{2}$
(*e*) $\frac{1}{100}$ (*j*) $\frac{1}{50}$

11. (*a*) 2 (*f*) -3
(*b*) -3 (*g*) $1\frac{1}{3}$
(*c*) 4 (*h*) $1\frac{1}{5}$
(*d*) -1 (*i*) 6
(*e*) 3

12. (*a*) As a increases y increases more rapidly and graph gets nearer the y axis.
(*b*) $y = 3^x$ would lie between $y = 2^x$ and $y = 4^x$.
$y = 5^x$ would lie between $y = 4^x$ and $y = 8^x$.
(*c*) The graph of $y = a^x$ approaches x axis more rapidly in the second quadrant as a increases.

13. (*a*) $x = 0$
(*b*) $x > 0, x \in R$
(*c*) $x < 0, x \in R$

14. y is doubled

15. 0.71, 0.0625

16. 141 421

17. (*a*) 51.532 331 61
(*b*) 0.648 938 4
(*c*) 10 663 734.4
(*d*) 0.000 137 793 1
(*e*) 302.916 636 5
(*f*) 0.000 000 105 4

18. (*a*) $5.557\,812\,578 \times 10^{11}$
(*b*) $4.918\,563 \times 10^{-15}$

19. (*a*) 1.063 292 64
(*b*) 79 927.066 45
(*c*) 0.007 137 857 9
(*d*) 0.000 006 371 2
(*e*) 0.503 372 062 8

20. (*a*) 6612.291 856
(*b*) 949.862 087
(*c*) 114 872.257
(*d*) 0.024 442 195 6
(*e*) 0.000 000 452 9
(*f*) $4.350\,348\,474 \times 10^{-18}$

21. (*a*) 12.973 048 99
(*b*) 4.384 900 03
(*c*) 15.190 132 11
(*d*) 0.037 841 775 8
(*e*) 0.359 082 023 3
(*f*) 0.169 795 581 1

22. (*a*) 0.001 300 507 1
(*b*) 0.025 041 374 5
(*c*) 0.134 041 768 9
(*d*) 1.589 595 378
(*e*) 0.809 063 834 2
(*f*) 1.166 464 749
(*g*) 2.808 782 135
(*h*) 0.198 471 453 3
(*i*) 1213.022 855
(*j*) 0.741 072 896 4
(*k*) 5.669 194 093
(*l*) $-1.608\,496\,951$

Chapter 6

Exercise 6.1, Page 230

4. No. No

5. $\{x \mid x \in R, x > 0\}$, R

6. (*a*) 4 (*h*) 0
(*b*) 3 (*i*) $\frac{1}{2}$
(*c*) 4 (*j*) 3
(*d*) 3 (*k*) $\frac{1}{2}$
(*e*) -2 (*l*) x
(*f*) -3
(*g*) -2

7. (*a*) 1 (*b*) 0

8. (*a*)

x	y
0	1
0.1	1.26
0.2	1.59
0.3	2.00
0.4	2.51
0.5	3.16
0.6	3.98
0.7	5.01
0.8	6.31
0.9	7.94
1.0	10

(*b*)

y	x
1	0
2	0.30
3	0.48
4	0.60
5	0.70
6	0.78
7	0.85
8	0.90
9	0.95
10	1

(*d*)

x	$\log_{10}x$
1	0
2	0.30
3	0.48
4	0.60
5	0.70
6	0.78
7	0.85
8	0.90
9	0.95
10	1

(*c*) 0.30

9. (*a*)

x	$\log_2 x$
$\frac{1}{4}$	-2
$\frac{1}{2}$	-1
1	0
2	1
4	2
8	3
16	4

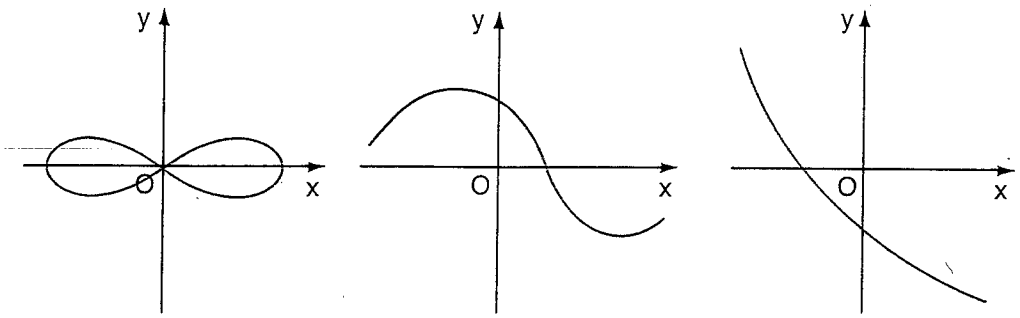
(*b*) The graph of $y = \log_2 x$ is the image of the graph of $y = 2^x$ in the line $y = x$.
(*c*) 2.6, 3.3, 3.6
(*d*) 1.6, 2.3, 3.9
$\log_2 3 + \log_2 5$
$= \log_2 15$

10. (*a*) 125 (*f*) $\frac{1}{2}$
(*b*) 6 (*g*) 6
(*c*) $\frac{1}{25}$ (*h*) $a \in R$
(*d*) 15 (*i*) -14
(*e*) 3 (*j*) -6

6.11 CHAPTER 6 TEST

1. Which of the following figures are graphs of functions? Which of the functions are one-to-one?

(a) (b) (c)



2. Find the domain of the function $f(x) = \dfrac{1}{\sqrt{x + 1}}$.

3. (a) Sketch the graph of $y = x^3$.
(b) Use part (a) to sketch the graph of $y = (x - 2)^3 + 1$.

4. Complete the square and use transformations to graph the function $y = 2x^2 + 12x + 15$.

5. How can the graph of $y = -2f(x)$ be obtained from the graph of f?

6. Classify each of the following functions as being even, odd, or neither.

(a) $f(x) = x^4 + 2x$ (b) $g(x) = x^4 + x^2$ (c) $h(x) = \dfrac{x}{x^2 + 1}$

7. If $f(x) = 3x^2 + 2x - 1$ and $g(x) = 1 - 3x$, find $f \circ g$ and $g \circ f$.

8. Find the inverse function of $f(x) = \sqrt{x + 5}$.

9. A taxi company charges \$1.00 for the first 0.2 km (or part) and 10¢ for each additional 0.1 km (or part).
(a) How much will it cost to travel 4.52 km by taxi?
(b) Express the cost (C) as a function of distance(x).
(c) Draw the graph of C(x) for $0 \leqslant x \leqslant 2$.