

## Chapter 1 Polynomial Functions

- What is meant by even symmetry? odd symmetry?
  - Describe how to determine whether a function has even or odd symmetry.
- Describe two key differences between polynomial functions and non-polynomial functions.
- Compare the end behaviour of the following functions. Explain any differences.

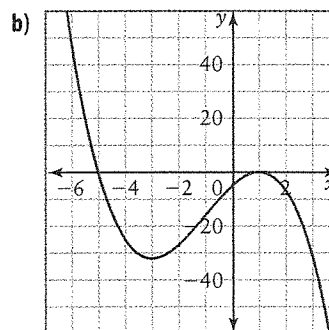
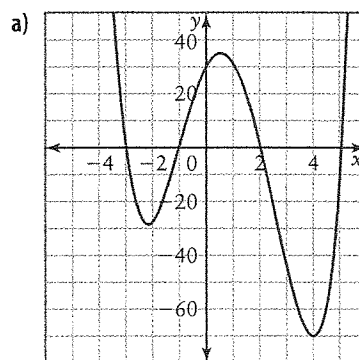
$$f(x) = -3x^2 \quad g(x) = 5x^4 \quad h(x) = 0.5x^3$$

- Determine the degree of the polynomial function modelling the following data.

x	y
-2	17
-1	-3
0	-3
1	-1
2	33
3	177

- Determine an equation and sketch a graph of the function with a base function of  $f(x) = x^4$  that has been transformed by  $-2f(x - 3) + 1$ .
- Sketch the functions  $f(x) = x^3$  and  $g(x) = -\frac{1}{2}(x - 1)(x + 2)^2$  on the same set of axes. Label the  $x$ - and  $y$ -intercepts. State the domain and range of each function.
- Consider the function  $f(x) = 2x^4 + 5x^3 - x^2 - 3x + 1$ .
  - Determine the average slope between the points where  $x = 1$  and  $x = 3$ .
  - Determine the instantaneous slope at each of these points.
  - Compare the three slopes and describe how the graph is changing.

- Determine an equation for each function.



- Given the function  $f(x) = -2x^2 + 1$ , describe the slope and the change in slope for the appropriate intervals.

## Chapter 2 Polynomial Equations and Inequalities

- Perform each division. Write the statement that can be used to check each division. State the restrictions.
  - $(4x^3 + 6x^2 - 4x + 2) \div (2x - 1)$
  - $(2x^3 - 4x + 8) \div (x - 2)$
  - $(x^3 - 3x^2 + 5x - 4) \div (x + 2)$
  - $(5x^4 - 3x^3 + 2x^2 + 4x - 6) \div (x + 1)$
- Factor, if possible.
  - $x^3 + 4x^2 + x - 6$
  - $2x^3 + x^2 - 16x - 15$
  - $x^3 - 7x^2 + 11x - 2$
  - $x^4 + x^2 + 1$

12. Use the remainder theorem to determine the remainder for each.
- $4x^3 - 7x^2 + 3x + 5$  divided by  $x - 5$
  - $6x^4 + 7x^2 - 2x - 4$  divided by  $3x + 2$
13. Use the factor theorem to determine whether the second polynomial is a factor of the first.
- $3x^5 - 4x^3 - 4x^2 + 15$ ;  $x + 5$
  - $2x^3 - 4x^2 + 6x + 5$ ;  $x + 1$
14. Solve.
- $x^4 - 81 = 0$
  - $x^3 - x^2 - 10x - 8 = 0$
  - $8x^3 + 27 = 0$
  - $12x^4 - 7x^2 - 6x + 16x^3 = 0$
15. A family of quartic functions has zeros  $-3$ ,  $-1$ , and  $1$  (order 2).
- Write an equation for the family. State two other members of the family.
  - Determine an equation for the member of the family that passes through the point  $(-2, -6)$ .
  - Sketch the function you found in part b).
  - Determine the intervals where the function in part b) is positive.
16. Solve each inequality, showing the appropriate steps. Illustrate your solution on a number line.
- $(x - 4)(x + 3) > 0$
  - $2x^2 + x - 6 < 0$
  - $x^3 - 2x^2 - 13x \leq 10$
18. For each function,
- determine equations for the asymptotes
  - determine the intercepts
  - sketch a graph
  - describe the increasing intervals and the decreasing intervals
  - state the domain and the range
- $f(x) = \frac{1}{x + 4}$
  - $g(x) = \frac{-4}{x - 2}$
  - $h(x) = \frac{x - 1}{x + 3}$
  - $i(x) = \frac{2x + 3}{5x + 1}$
  - $j(x) = \frac{10}{x^2}$
  - $k(x) = \frac{3}{x^2 - 6x - 27}$
19. Analyse the slope and the change in slope for the appropriate intervals of the function  $f(x) = \frac{1}{x^2 - 4x - 21}$ . Sketch a graph of the function.
20. Solve algebraically.
- $\frac{5}{x - 3} = 4$
  - $\frac{2}{x - 1} = \frac{4}{x + 5}$
  - $\frac{6}{x^2 + 4x + 7} = 2$
21. Solve each inequality. Illustrate the solution on a number line.
- $\frac{3}{x - 4} < 5$
  - $\frac{x^2 - 8x + 15}{x^2 + 5x + 4} \geq 0$
22. A lab technician pours a quantity of a chemical into a beaker of water. The rate,  $R$ , in grams per second, at which the chemical dissolves can be modelled by the function  $R(t) = \frac{2t}{t^2 + 4t}$ , where  $t$  is the time, in seconds.
- By hand or using technology, sketch a graph of this relation.
  - What is the equation of the horizontal asymptote? What is its significance?
  - State an appropriate domain for this relation if a rate of  $0.05$  g/s or less is considered to be inconsequential.

### Chapter 3 Rational Functions

17. Determine equations for the vertical and horizontal asymptotes of each function.
- $f(x) = \frac{1}{x - 2}$
  - $g(x) = \frac{x + 5}{x + 3}$
  - $h(x) = \frac{2}{x^2 - 9}$
  - $k(x) = \frac{-1}{x^2 + 4}$

## Chapter 4 Trigonometry

23. Determine the exact radian measure for each angle.  
a)  $135^\circ$     b)  $-60^\circ$
24. Determine the exact degree measure for each angle.  
a)  $\frac{\pi}{6}$     b)  $\frac{9\pi}{8}$
25. A sector angle of a circle with radius 9 cm measures  $\frac{5\pi}{12}$ . What is the perimeter of the sector?
26. Determine the exact value of each trigonometric ratio.  
a)  $\cos \frac{5\pi}{6}$     b)  $\sin \frac{3\pi}{2}$   
c)  $\tan \frac{4\pi}{3}$     d)  $\cot \frac{11\pi}{4}$
27. Use the sum or difference formulas to find the exact value of each.  
a)  $\cos \frac{\pi}{12}$     b)  $\sin \frac{11\pi}{12}$
28. Prove each identity.  
a)  $\sec x - \tan x = \frac{1 - \sin x}{\cos x}$   
b)  $(\csc x - \cot x)^2 = \frac{1 - \cos x}{1 + \cos x}$   
c)  $\sin 2A = \frac{2 \tan A}{\sec^2 A}$   
d)  $\cos(x + y) \cos(x - y) = \cos^2 x + \cos^2 y - 1$
29. Given  $\sin x = \frac{1}{5}$  and  $\sin y = \frac{5}{6}$ , where  $x$  and  $y$  are acute angles, determine the exact value of  $\sin(x + y)$ .
30. Given that  $\cos \frac{5\pi}{8} = -\sin y$ , first express  $\frac{5\pi}{8}$  as a sum of  $\frac{\pi}{2}$  and an angle, and then apply a trigonometric identity to determine the measure of angle  $y$ .

## Chapter 5 Trigonometric Functions

31. a) State the period, amplitude, phase shift, and vertical translation for the function  $f(x) = 3 \sin \left[ 2 \left( x - \frac{\pi}{2} \right) \right] + 4$ .  
b) State the domain and the range of  $f(x)$ .

32. Sketch a graph of each function for one period. Label the  $x$ -intercepts and any asymptotes.

a)  $f(x) = \sin(x - \pi) - 1$   
b)  $f(x) = -3 \cos \left[ 4 \left( x + \frac{\pi}{2} \right) \right]$   
c)  $f(x) = \sec \left( x - \frac{\pi}{2} \right)$

33. Solve for  $\theta \in [0, 2\pi]$ .

a)  $2 \sin \theta = -\sqrt{3}$   
b)  $2 \sin \theta \cos \theta - \cos \theta = 0$   
c)  $\csc^2 \theta = 2 + \csc \theta$

34. The blade of a sabre saw moves up and down. Its vertical displacement in the first cycle is shown in the table.

Time (s)	Displacement (cm)
0	0
0.005	0.64
0.01	1.08
0.015	1.19
0.02	0.92
0.025	0.37
0.03	-0.30
0.035	-0.87
0.04	-1.18
0.045	-1.12
0.05	-0.71
0.055	-0.08
0.06	0.58
0.065	1.05
0.07	1.19

- a) Make a scatter plot of the data.  
b) Write a sine function to model the data.  
c) Graph the sine function on the same set of axes as in part a).  
d) Estimate the rate of change when the displacement is 0 cm, to one decimal place.

## Chapter 6 Exponential and Logarithmic Functions

35. Express in logarithmic form.

a)  $7^2 = 49$     b)  $a^b = c$   
c)  $8^3 = 512$     d)  $11^x = y$

36. a) Sketch graphs of  $f(x) = \log x$  and  $g(x) = \frac{1}{2} \log(x + 1)$  on the same set of axes. Label the intercepts and any asymptotes.  
b) State the domain and the range of each function.
37. Express in exponential form.  
a)  $\log_3 6561 = 8$       b)  $\log_a 75 = b$   
c)  $\log_7 2401 = 4$       d)  $\log_a 19 = b$
38. Evaluate.  
a)  $\log_2 256$       b)  $\log_{15} 15$   
c)  $\log_6 \sqrt{6}$       d)  $\log_3 243$   
e)  $\log_{12} 12$       f)  $\log_{11} \frac{1}{\sqrt{121}}$
39. Solve for  $x$ .  
a)  $\log_3 x = 4$       b)  $\log_x 125 = 3$   
c)  $\log_7 x = 5$       d)  $\log_x 729 = 6$   
e)  $\log_{\frac{1}{2}} 128 = x$       f)  $\log_{\frac{1}{4}} 64 = x$
40. A culture begins with 100 000 bacteria and grows to 125 000 bacteria after 20 min. What is the doubling period, to the nearest minute?
41. The pH scale is defined as  $\text{pH} = -\log[H^+]$ , where  $[H^+]$  is the concentration of hydronium ions, in moles per litre.  
a) Eggs have a pH of 7.8. Are eggs acidic or alkaline? What is the concentration of hydronium ions in eggs?  
b) A weak vinegar solution has a hydronium ion concentration of  $7.9 \times 10^{-4}$  mol/L. What is the pH of the solution?
42. Solve each equation. Check for extraneous roots.  
a)  $3^{2x} + 3^x - 21 = 0$   
b)  $4^x + 15(4)^{-x} = 8$
43. Use the laws of logarithms to evaluate.  
a)  $\log_8 4 + \log_8 128$       b)  $\log_7 7\sqrt{7}$   
c)  $\log_5 10 - \log_5 250$       d)  $\log_6 \sqrt[3]{6}$
44. Solve, correct to four decimal places.  
a)  $2^x = 13$       b)  $5^{2x+1} = 97$   
c)  $3^x = 19$       d)  $4^{3x+2} = 18$
45. Solve. Check for extraneous roots.  
a)  $\log_5(x + 2) + \log_5(2x - 1) = 2$   
b)  $\log_4(x + 3) + \log_4(x + 4) = \frac{1}{2}$
46. Determine the point(s) of intersection of the functions  $f(x) = \log x$  and  $g(x) = \frac{1}{2} \log(x + 1)$ .
47. Bismuth is used in making chemical alloys, medicine, and transistors. A 10-mg sample of bismuth-214 decays to 9 mg in 3 min.  
a) Determine the half-life of bismuth-214.  
b) How much bismuth-214 remains after 10 min?  
c) Graph the amount of bismuth-214 remaining as a function of time.  
d) Describe how the graph would change if the half-life were shorter. Give reasons for your answer.
48. The volume of computer parts in landfill sites is growing exponentially. In 2001, a particular landfill site had 124 000 m<sup>3</sup> of computer parts, and in 2007, it had 347 000 m<sup>3</sup> of parts.  
a) What is the doubling time of the volume of computer parts in this landfill site?  
b) What is the expected volume of computer parts in this landfill site in 2020?
49. The value of a particular model of car depreciates by 18% per year. This model of car sells for \$35 000.  
a) Write an equation to relate the value of the car to the time, in years.  
b) Determine the value of the car after 5 years.  
c) How long will it take for the car to depreciate to half its original value?  
d) Sketch a graph of this relation.  
e) Describe how the shape of the graph would change if the rate of depreciation changed to 25%.

## Chapter 7 Tools and Strategies for Solving Exponential and Logarithmic Equations

## Chapter 8 Combining Functions

50. Consider  $f(x) = 2^{-\frac{x}{\pi}}$  and  $g(x) = 2\cos(4x)$  for  $x \in [0, 4\pi]$ . Sketch a graph of each function.

a)  $y = f(x) + g(x)$       b)  $y = f(x) - g(x)$

c)  $y = f(x)g(x)$       d)  $y = \frac{f(x)}{g(x)}$

51. Given  $f(x) = 2x^2 + 3x - 5$  and  $g(x) = x + 3$ , determine each of the following.

a)  $f(g(x))$       b)  $g(f(x))$

c)  $f(g(-3))$       d)  $g(f(7))$

52. If  $f(x) = \frac{1}{x}$  and  $g(x) = 4 - x$ , determine each of the following, if it exists.

a)  $f(g(3))$       b)  $f(g(0))$

c)  $f(g(4))$       d)  $g(f(4))$

53. Find expressions for  $f(g(x))$  and  $g(f(x))$ , and state their domains.

a)  $f(x) = \sqrt{x}$ ,  $g(x) = x + 1$

b)  $f(x) = \sin x$ ,  $g(x) = x^2$

c)  $f(x) = |x|$ ,  $g(x) = x^2 - 6$

d)  $f(x) = 2^{x+1}$ ,  $g(x) = 3x + 2$

e)  $f(x) = (x + 3)^2$ ,  $g(x) = \sqrt{x - 3}$

f)  $f(x) = \log x$ ,  $g(x) = 3^{x+1}$

54. Consider  $f(x) = -\frac{2}{x}$  and  $g(x) = \sqrt{x}$ .

a) Determine  $f(g(x))$ .

b) State the domain of  $f(g(x))$ .

c) Determine whether  $f(g(x))$  is even, odd, or neither.

55. Verify, algebraically, that  $f(f^{-1}(x)) = x$  for each of the following.

a)  $f(x) = x^2 - 4$

b)  $f(x) = \sin x$

c)  $f(x) = 3x$

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

56. Solve. Illustrate each inequality graphically.

a)  $\sin x < 0.1x^2 - 1$

b)  $x + 2 \geq 2^x$

57. A Ferris wheel rotates such that the angle of rotation,  $\theta$ , is defined by  $\theta = \frac{\pi t}{15}$ , where  $t$  is the time, in seconds. A rider's height,  $h$ , in metres, above the ground can be modelled by the function  $h(\theta) = 20\sin \theta + 22$ .

a) Write an equation for the rider's height in terms of time.

b) Sketch graphs of the three functions, on separate sets of axes, one above the other.

c) Compare the periods of the graphs of  $h(\theta)$  and  $h(t)$ .

58. An office chair manufacturer models its weekly production since 2001 by the function  $N(t) = 100 + 25t$ , where  $t$  is the time, in years, since 2001, and  $N$  is the number of chairs. The size of the manufacturer's workforce can be modelled by the function  $W(N) = 3\sqrt{N}$ .

a) Write the size of the workforce as a function of time.

b) State the domain and range of the function in part a) that is relevant to this problem. Sketch its graph.

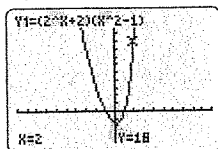
59. An environmental scientist measures the pollutant in a lake. The concentration,  $C(P)$ , in parts per million (ppm), of pollutant can be modelled as a function of the population,  $P$ , of the lakeside city, by  $C(P) = 1.28P + 53.12$ . The city's population, in ten thousands, can be modelled by the function  $P(t) = 12.5 \times 2^{\frac{t}{20}}$ , where  $t$  is the time, in years.

a) Determine an equation for the concentration of pollutant as a function of time.

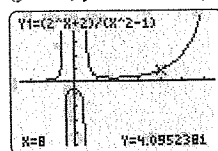
b) Sketch a graph of this function.

c) How long will it take for the concentration to reach 100 ppm?

d)  $y = (2^x + 2)(x^2 - 1)$ ;  $\{x \in \mathbb{R}, \{y \in \mathbb{R}, y \geq -3.04\}$

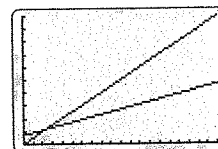


d)  $y = \frac{2^x + 2}{x^2 - 1}$ ;  $\{x \in \mathbb{R}, x \neq -1, x \neq 1\}$ ,  
 $\{y \in \mathbb{R}, y \leq -2.96, y > 0\}$



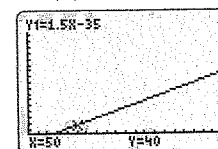
17. a) i)  $C(n) = 35 + n$ ,  $0 \leq n \leq 200$

ii)  $R(n) = 2.5n$ ,  $0 \leq n \leq 200$  b) Window variables:  
 $x \in [0, 200]$ , Xscl 10,  $y \in [0, 500]$ , Yscl 50



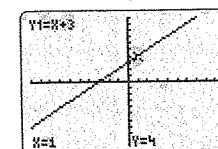
c) (23.33, 58.33); Kathy makes a profit if she sells 24 or more cups of apple cider. Kathy loses money if she sells 23 or fewer cups of apple cider.

d)  $P(n) = 1.5n - 35$

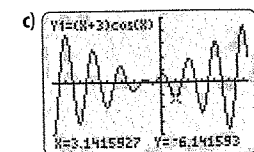
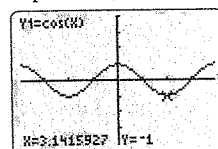


e) \$265

18. a) linear; neither



b) periodic; even

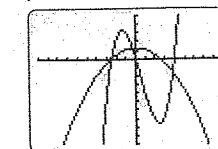


e)  $\{x \in \mathbb{R}, \{y \in \mathbb{R}\}$

19. a)  $y = \frac{\sqrt{1-9x^2}}{x}$ ;  $\{x \in \mathbb{R}, -\frac{1}{3} \leq x < 0, 0 < x \leq \frac{1}{3}\}$ ,

$\{y \in \mathbb{R}\}$  b)  $y = \frac{1}{x-9}$ ;  $\{x \in \mathbb{R}, x > 9\}, \{y \in \mathbb{R}, y > 0\}$

20. a) Window variables:  $x \in [-20, 20]$ , Xscl 2,  
 $y \in [-200, 100]$ , Yscl 20



b)  $[-5, -0.65]$  or  $(7.65, \infty)$

## Course Review, pages 479–483

1. a) An even function is symmetric with respect to the y-axis. An odd function is symmetric with respect to the origin.

b) Substitute  $-x$  for  $x$  in  $f(x)$ . If  $f(-x) = f(x)$ , the function is even. If  $f(-x) = -f(x)$ , the function is odd.

2. Answers may vary. Sample answer: A polynomial function has the form  $f(x) = a_n x^n + a_{n-1} x^{n-1} + \dots + a_1 x + a_0$ .

For a polynomial function of degree  $n$ , where  $n$  is a positive integer, the  $n$ th differences are equal (or constant).

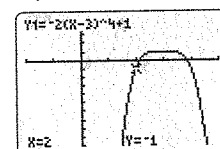
3.  $f(x)$  extends from quadrant 3 to quadrant 4; even exponent, negative coefficient

$g(x)$  extends from quadrant 2 to quadrant 1; even exponent, positive coefficient

$h(x)$  extends from quadrant 3 to quadrant 1; odd exponent, positive coefficient

4. 4

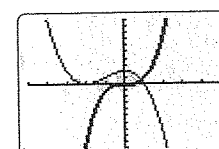
5.  $y = -2(x-3)^4 + 1$



6.  $f(x)$ : x-intercept 0, y-intercept 0,  $\{x \in \mathbb{R}, \{y \in \mathbb{R}\}$

$g(x)$ : x-intercepts  $-2$  and  $1$ , y-intercept  $2$ ,  $\{x \in \mathbb{R}, \{y \in \mathbb{R}\}$

Window variables:  $x \in [-20, 20]$ , Xscl 2,  $y \in [-200, 100]$ , Yscl 20



7. a) 138 b) 18; 342 c) The graph is increasing for  $1 < x < 3$ .

8. a)  $y = (x+3)(x+1)(x-2)(x-5)$  b)  $y = -(x+5)(x-1)^2$

9. For  $x < 0$ , the slope is positive and decreasing. For  $x > 0$ , the slope is negative and decreasing.

10. a)  $\frac{4x^3 + 6x^2 - 4x + 2}{2x - 1} = 2x^2 + 4x + \frac{2}{2x - 1}$ ,  
 $x \neq \frac{1}{2}$

b)  $\frac{2x^3 - 4x + 8}{x - 2} = 2x^2 + 4x + 4 + \frac{16}{x - 2}$ ,  $x \neq 2$

c)  $\frac{x^3 - 3x^2 + 5x - 4}{x + 2} = x^2 - 5x + 15 + \frac{-34}{x + 2}$ ,  $x \neq -2$

d)  $\frac{5x^4 - 3x^3 + 2x^2 + 4x - 6}{x + 1} = 5x^3 - 8x^2 + 10x - 6$ ,  $x \neq -1$

11. a)  $(x-1)(x+2)(x+3)$  b)  $(x-3)(x+1)(2x+5)$

c)  $(x-2)(x^2-5x+1)$  d)  $(x^2+x+1)(x^2-x+1)$

12. a) 345 b)  $\frac{44}{27}$

13. a) No. b) No.

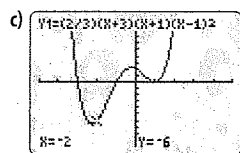
14. a)  $-3, 3$  b)  $-2, -1, 4$  c)  $-\frac{3}{2}$  d)  $-\frac{3}{2}, -\frac{1}{2}, 0, \frac{2}{3}$

15. a) Answers may vary. Sample answer:

$y = k(x+3)(x+1)(x-1)^2$ ;  $y = 2(x+3)(x+1)(x-1)^2$ ,

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

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



d)  $x < -3, -1 < x < 1, x > 1$

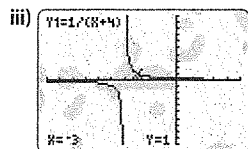
16. a)  $x < -3$  or  $x > 4$  b)  $-2 < x < \frac{3}{2}$

c)  $x \leq -2$  or  $-1 \leq x \leq 5$

17. a)  $x = 2, y = 0$  b)  $x = -3, y = 1$

c)  $x = -3, x = 3, y = 0$  d)  $y = 0$

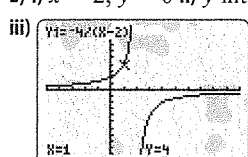
18. a) i)  $x = -4, y = 0$  ii) y-intercept  $\frac{1}{4}$



iv) decreasing for  $x < -4$  and  $x > -4$

v)  $\{x \in \mathbb{R}, x \neq -4\}, \{y \in \mathbb{R}, y \neq 0\}$

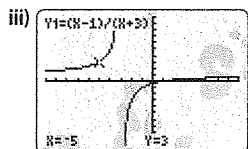
b) i)  $x = 2, y = 0$  ii) y-intercept 2



iv) increasing for  $x < 2$  and  $x > 2$

v)  $\{x \in \mathbb{R}, x \neq 2\}, \{y \in \mathbb{R}, y \neq 0\}$

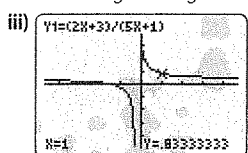
c) i)  $x = -3, y = 1$  ii) y-intercept  $-\frac{1}{3}$ , x-intercept 1



iv) increasing for  $x < -3$  and  $x > -3$

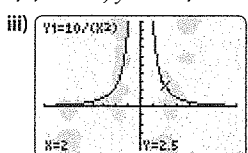
v)  $\{x \in \mathbb{R}, x \neq -3\}, \{y \in \mathbb{R}, y \neq 1\}$

d) i)  $x = -\frac{1}{5}, y = \frac{2}{5}$  ii) y-intercept 3, x-intercept  $-\frac{3}{2}$



iv) decreasing for  $x < -\frac{1}{5}$  and  $x > -\frac{1}{5}$  v)  $\{x \in \mathbb{R}, x \neq -\frac{1}{5}\}, \{y \in \mathbb{R}, y \neq \frac{2}{5}\}$

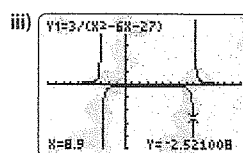
e) i)  $x = 0, y = 0$  ii) no intercepts



iv) increasing for  $x < 0$ , decreasing for  $x > 0$

v)  $\{x \in \mathbb{R}, x \neq 0\}, \{y \in \mathbb{R}, y > 0\}$

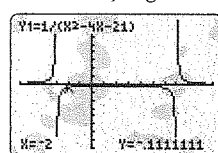
f) i)  $x = -3, x = 9, y = 0$  ii) y-intercept  $-\frac{1}{9}$



iv) increasing for  $x < -3$  and  $-3 < x < 3$ , decreasing for  $3 < x < 9$  and  $x > 9$

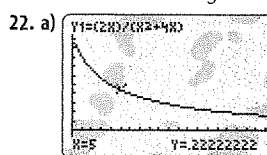
v)  $\{x \in \mathbb{R}, x \neq -3, x \neq 9\}, \{y \in \mathbb{R}, y \leq -\frac{1}{12}, y > 0\}$

19. positive increasing slope for  $x < -3$ , positive decreasing slope for  $-3 < x < 2$ , negative decreasing slope for  $2 < x < 7$ , negative increasing slope for  $x > 7$



20. a)  $\frac{17}{4}$  b) 7 c) -2

21. a)  $x < 4$  or  $x > \frac{23}{5}$  b)  $x < -4$  or  $-1 < x \leq 3$  or  $x \geq 5$



b)  $R(t) = 0$ ; The chemical will not completely dissolve.

c)  $\{t \in \mathbb{R}, 0 \leq t < 36\}$

23. a)  $\frac{3\pi}{4}$  b)  $-\frac{\pi}{3}$

24. a)  $30^\circ$  b)  $202.5^\circ$

25.  $\frac{15\pi + 72}{4}$

26. a)  $-\frac{\sqrt{3}}{2}$  b) -1 c)  $\sqrt{3}$  d) -1

27. a)  $\frac{1 + \sqrt{3}}{2\sqrt{2}}$  b)  $\frac{\sqrt{3} - 1}{2\sqrt{2}}$

29.  $\frac{\sqrt{11} + 10\sqrt{6}}{30}$

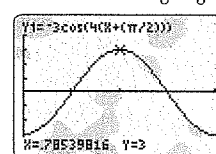
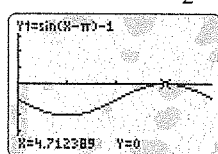
30.  $\frac{\pi}{8}$

31. a) period  $\pi$ , amplitude 3, phase shift  $\frac{\pi}{2}$  rad to the right, vertical translation 4 units upward

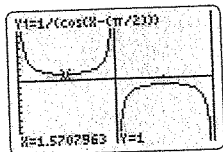
b)  $\{x \in \mathbb{R}\}, \{y \in \mathbb{R}, 1 \leq y \leq 7\}$

32. a) x-intercept  $\frac{3\pi}{2}$

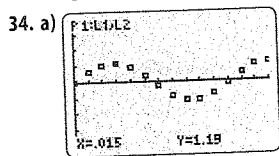
b) x-intercepts  $\frac{\pi}{8}, \frac{3\pi}{8}$



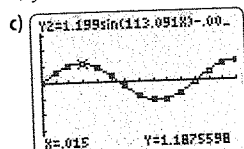
c) asymptotes  $x = 0$ ,  $x = \pi$ ,  $x = 2\pi$



33. a)  $\frac{4\pi}{3}$ ,  $\frac{5\pi}{3}$  b)  $\frac{\pi}{6}$ ,  $\frac{\pi}{2}$ ,  $\frac{5\pi}{6}$ ,  $\frac{3\pi}{2}$  c)  $\frac{\pi}{6}$ ,  $\frac{5\pi}{6}$ ,  $\frac{3\pi}{2}$



b)  $y = 1.199 \sin(113.091x) - 0.002$



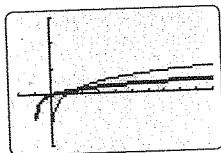
d) 135.6 cm/s

35. a)  $\log_7 49 = 2$  b)  $\log_8 c = b$  c)  $\log_8 512 = 3$  d)  $\log_{11} y = x$

36. a)  $f(x)$ : x-intercept 1, asymptote  $x = 0$

$g(x)$ : x-intercept 0, y-intercept 0, asymptote  $x = -1$

Window variables:  $x \in [-2, 10]$ ,  $y \in [-2, 3]$



b)  $f(x)$ :  $\{x \in \mathbb{R}, x > 0\}$ ,  $\{y \in \mathbb{R}\}$ ;  $g(x)$ :  $\{x \in \mathbb{R}, x > -1\}$ ,  $\{y \in \mathbb{R}\}$

37. a)  $3^8 = 6561$  b)  $a^b = 75$  c)  $7^4 = 2401$  d)  $a^b = 19$

38. a) 8 b) 1 c)  $\frac{1}{2}$  d) 5 e) 1 f) -1

39. a) 81 b) 5 c) 16 807 d) 3 e) -7 f) -3

40. 62 min

41. a) alkaline,  $1.585 \times 10^{-8}$  mol/L b) 3.1

42. a)  $x \approx 1.29$  b)  $x \approx 0.79$  or  $x \approx 1.16$

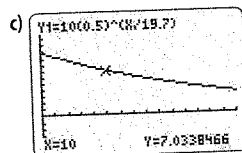
43. a) 3 b)  $\frac{3}{2}$  c) -2 d)  $\frac{1}{3}$

44. a) 3.7004 b) 0.9212 c) 2.6801 d) 0.0283

45. a) 3 b) -2

46. (1.62, 0.21)

47. a)  $h \approx 19.7$  min b) approximately 7.03 mg

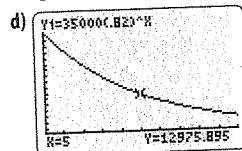


d) Answers may vary. Sample answer: The graph would decrease faster because the sample would be decreasing at a faster rate.

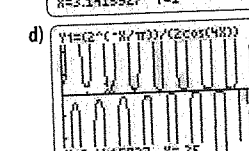
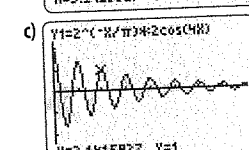
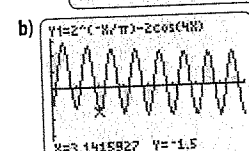
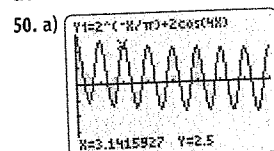
48. a)  $d \approx 4.04$  years b) approximately 3 229 660

49. a)  $y = 35\,000(0.82)^t$  b) \$12 975.89

c) approximately 3.5 years



e) Answers may vary. Sample answer: The graph would decrease faster.



51. a)  $2x^2 + 15x + 22$  b)  $2x^2 + 3x - 2$  c) -5 d) 117

52. a) 1 b)  $\frac{1}{4}$  c) does not exist d)  $\frac{15}{4}$

53. a)  $f(g(x)) = \sqrt{x+1}$ ,  $\{x \in \mathbb{R}, x \geq -1\}$ ;

$g(f(x)) = \sqrt{x} + 1$ ,  $\{x \in \mathbb{R}, x \geq 0\}$

b)  $f(g(x)) = \sin(x^2)$ ,  $\{x \in \mathbb{R}\}$ ;  $g(f(x)) = \sin^2 x$ ,  $\{x \in \mathbb{R}\}$

c)  $f(g(x)) = |x^2 - 6|$ ,  $\{x \in \mathbb{R}\}$ ;  $g(f(x)) = |x|^2 - 6$ ,  $\{x \in \mathbb{R}\}$

d)  $f(g(x)) = 2^{(3x+3)}$ ,  $\{x \in \mathbb{R}\}$ ;  $g(f(x)) = 3(2^{x+1}) + 2$ ,  $\{x \in \mathbb{R}\}$

e)  $f(g(x)) = 6\sqrt{x-3} + x + 6$ ,  $\{x \in \mathbb{R}, x \geq 3\}$ ;

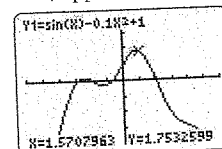
$g(f(x)) = \sqrt{x^2 + 6x + 6}$ ,  $\{x \in \mathbb{R}, x \leq -3 - \sqrt{3}$ ,

$x \geq -3 + \sqrt{3}\}$  f)  $f(g(x)) = (x+1)\log 3$ ,  $\{x \in \mathbb{R}\}$ ;

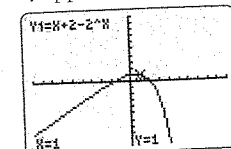
$g(f(x)) = 3^{\log x + 1}$ ,  $\{x \in \mathbb{R}, x > 0\}$

54. a)  $y = -\frac{2}{\sqrt{x}}$  b)  $\{x \in \mathbb{R}, x > 0\}$  c) neither

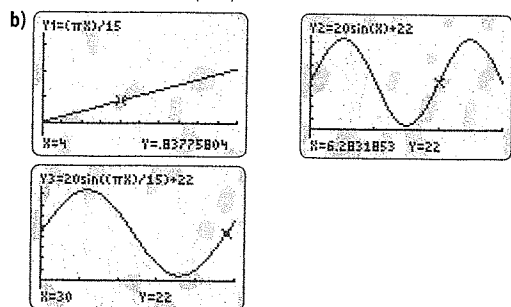
56. a) approximately  $(-\infty, -4.43)$  or  $(-3.11, -1.08)$  or  $(3.15, \infty)$



b) approximately  $[-1.69, 2]$



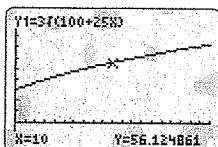
57. a)  $b(t) = 20 \sin\left(\frac{\pi t}{15}\right) + 22$



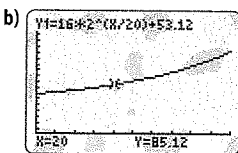
c) The period of  $b(t)$  is  $2\pi$  rad. The period of  $b(t)$  is 30 s.

58. a)  $W(t) = 3\sqrt{100 + 25t}$

b)  $(t \in \mathbb{R}, t \geq 0), \{W \in \mathbb{Z}, W \geq 30\}$



59. a)  $C(t) = 16 \times 2^{\frac{t}{20}} + 53.12$



c) approximately 31 years

## PREREQUISITE SKILLS APPENDIX ANSWERS

### Angles From Trigonometric Ratios, page 484

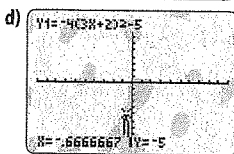
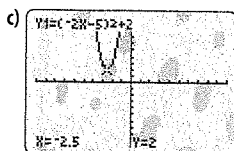
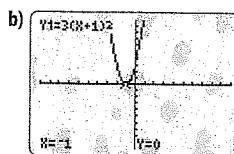
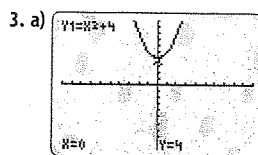
1. a)  $18.8^\circ$  b)  $136.5^\circ$  c)  $70.0^\circ$  d)  $-40.9^\circ$  e)  $75.7^\circ$  f)  $-74.4^\circ$

### Apply the Exponent Laws, pages 484–485

1. a)  $\frac{5}{x^3}$  b)  $\frac{1}{81x^4}$  c)  $7 + \frac{1}{x^6}$  d)  $\frac{1}{25}x^6 - \frac{6}{x} + 2x - x^3$   
 2. a)  $9x^{\frac{9}{2}} + 6x^{\frac{5}{2}} + x^{\frac{1}{2}}$  b)  $6x^5 + 9x^4 - 10x - 15$   
 c)  $4x^6 - 4x^4 + 8x^3 - 8x$  d)  $\sqrt{2x^3 - 4x^2 + 10x - 20}$   
 3. a) 81 b)  $\frac{1}{1024}$  c) 1 d) 6 e) 125  
 4. a)  $20x^9y^7$  b)  $b^3c^3$ ,  $a, b, c \neq 0$  c)  $m^{-5}n^2$ ,  $m, n \neq 0$   
 d)  $xy^{-4}$ ,  $x, y \neq 0$

### Apply Transformations to Functions, pages 485–486

1. a) vertical translation b) vertical stretch c) horizontal compression d) vertical reflection e) horizontal translation  
 f) horizontal reflection g) horizontal translation h) horizontal stretch i) vertical translation j) vertical stretch  
 2. a) vertical stretch by a factor of 3 and horizontal reflection in the y-axis  
 b) vertical translation downward by 3 units and horizontal compression by a factor of  $\frac{1}{2}$   
 c) horizontal translation left by 2 units and vertical reflection in the x-axis  
 d) vertical compression by a factor of  $\frac{1}{3}$ , horizontal compression by a factor of  $\frac{1}{5}$ , and horizontal reflection in the y-axis



### Determine Equations of Quadratic Functions, page 486

1. a)  $f(x) = 2(x-1)(x-5)$  b)  $f(x) = -(x+2)(x-1)$   
 c)  $f(x) = 1.5(x+6)(x+1)$  d)  $f(x) = 0.5(x+3)(x-0.5)$

### Determine Intervals From Graphs, page 487

1. a) x-intercepts  $-2$  and  $2$ ; above the x-axis for  $-2 < x < 2$ ; below the x-axis for  $x < -2$  and  $x > 2$   
 b) x-intercepts  $-3$ ,  $0$ , and  $3$ ; above the x-axis for  $-3 < x < 0$  and  $x > 3$ ; below the x-axis for  $x < -3$  and  $0 < x < 3$

### Distance Between Two Points, page 487

1. a)  $3\sqrt{2}$  b)  $\sqrt{65}$  c)  $\sqrt{74}$  d)  $3\sqrt{5}$  e)  $3\sqrt{5}$  f)  $\sqrt{82}$

### Domain and Range, page 488

1. a)  $\{x \in \mathbb{R}\}, \{y \in \mathbb{R}\}$   
 b)  $\{x \in \mathbb{R}\}, \{y \in \mathbb{R}\}$   
 c)  $\{x \in \mathbb{R}\}, \{y \in \mathbb{R}, y \geq -1\}$   
 d)  $\{x \in \mathbb{R}\}, \{y \in \mathbb{R}, y \geq 4\}$   
 e)  $\{x \in \mathbb{R} \mid x \geq -5\}, \{y \in \mathbb{R}, y \geq 0\}$   
 f)  $\{x \in \mathbb{R}, x \geq 2\}, \{y \in \mathbb{R}, y \geq 0\}$   
 g)  $\{x \in \mathbb{R}, x \neq -2\}, \{y \in \mathbb{R}, y \neq 0\}$   
 h)  $\{x \in \mathbb{R}, x \neq 1\}, \{y \in \mathbb{R}, y \neq 0\}$

### Equation of a Line, pages 488–489

1. a)  $y = 2x + 1$  b)  $y = -4x + 4$   
 2. a)  $y = 3x - 1$  b)  $y = -x - 3$   
 3. a)  $y = \frac{7}{2}x + \frac{3}{2}$  b)  $y = -x + 8$   
 4. a)  $y = -4x + 4$  b)  $y = \frac{2}{3}x - 2$

### Evaluate Functions, pages 489–490

1. a)  $-7$  b) 35 c) 5 d)  $-\frac{89}{27}$  e) 39.221 f)  $n^3 + 3n^2 - 4n - 7$   
 g)  $-27x^3 + 27x^2 + 12x - 7$  h)  $x^6 + 3x^4 - 4x^2 - 7$   
 2. a)  $-1$  b) 20 c) 2 d)  $x^2 + 4x - 1$   
 3. a) 0 b) 2 c) 1 d)  $\sqrt{x^2 - 3}$   
 4. a) 5 b) 2 c) 10 d) 0  
 5. a) true b) false c) true d) false