

# Honors PreCalculus



## Extra Practice Problems

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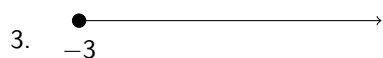
# Chapter 1

## Basic Set Theory and Interval Notation

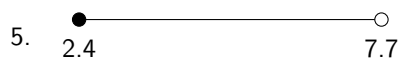
You are given either interval notation, set-builder notation, or a graph. Write each of the following in its other 2 forms.

1.  $(-5, 8]$

2.  $\{x|x \leq 1\}$



4.  $\{x|x \neq 4, 11\}$



6.  $(9, \infty)$

Write each using interval notation and graph on a number line.

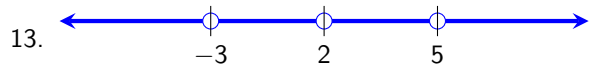
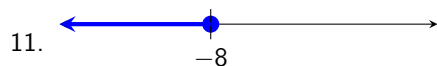
7.  $\{x|x \geq 2\}$

8.  $\{x|x < -8\}$

9.  $\{x|x \neq 3\}$

10.  $\{x|x \neq -2, 5\}$

You are given the graph of an interval. Write the interval and set-builder notation for it.



## 1.1 Answer Key

1.  $\{x | -5 < x \leq 8\}$



2.  $(-\infty, 1]$



3.  $[-3, \infty)$      $\{x | x \geq -3\}$

4.  $(-\infty, 4) \cup (4, 11) \cup (11, \infty)$



5.  $[2.4, 7.7)$      $\{x | 2.4 \leq x < 7.7\}$

6.  $\{x | x > 9\}$



7.  $[2, \infty)$



8.  $(-\infty, -8)$



9.  $(-\infty, 3) \cup (3, \infty)$



10.  $(\infty, -2) \cup (-2, 5) \cup (5, \infty)$



11.  $(-\infty, -8]$      $\{x | x \leq -8\}$

12.  $(-\infty, 7) \cup (7, 12) \cup (12, \infty)$      $\{x | x \neq 7, 12\}$

13.  $(-\infty, -3) \cup (-3, 2) \cup (2, 5) \cup (5, \infty)$      $\{x | x \neq -3, 2, 5\}$

# Chapter 2

## Functions and Their Graphs

### 2.1 Evaluating Functions

Given  $f(x) = -3x^2 + 4x$  and  $g(x) = \frac{1}{x} - 5$ , evaluate each.

- |                       |                       |                 |
|-----------------------|-----------------------|-----------------|
| 1. $f(5)$             | 2. $f(-2)$            | 3. $f(0)$       |
| 4. $g(1)$             | 5. $g(-5)$            | 6. $g(1/4)$     |
| 7. $f(-x)$            | 8. $g(-x)$            | 9. $f(2x)$      |
| 10. $g(2x)$           | 11. $f(x - 3)$        | 12. $g(x - 3)$  |
| 13. $f(\frac{1}{3}x)$ | 14. $g(\frac{1}{3}x)$ | 15. $f(2x + 1)$ |
| 16. $g(2x + 1)$       | 17. $f(-x + 7)$       | 18. $g(-x + 7)$ |

### 2.2 Domain of Functions

Find the domain of each write your answers in interval notation.

- |  |  |  |
|--|--|--|
| 1. $f(x) = -8x^2 - 7x + 1$                         | 2. $g(x) = \sqrt{5x + 12} - 2$           | 3. $h(x) = \frac{x+2}{9x-7}$           |
| 4. $f(x) = -5x + 4$                                | 5. $f(x) = x^2 + 2$                      | 6. $f(x) = \frac{2x+1}{3x-5}$          |
| 7. $f(x) = \sqrt{3x - 12}$                         | 8. $f(x) = \frac{x}{x^2-16}$             | 9. $f(x) = \frac{x+4}{x^3-4x}$         |
| 10. $f(x) = \frac{x}{\sqrt{x-4}}$                  | 11. $f(x) = \frac{x^2+1}{2x^2+8}$        | 12. $f(x) = -\frac{x+7}{x^2-5x-6}$     |
| 13. $g(x) = \sqrt{2x+3}$                           | 14. $h(x) = \sqrt[3]{2x+3}$              | 15. $f(x) = -\frac{7x-10}{x^2+3x+2}$   |
| 16. $g(x) = \sqrt{-9x+8}$                          | 17. $h(x) = -\sqrt[3]{4x+1}$             | 18. $f(x) = \sqrt[3]{8x+1}$            |
| 19. $g(x) = \frac{x^2-1}{\sqrt{x+3}}$              | 20. $h(x) = \frac{3}{9+\frac{4}{x+7}}$   | 21. $f(x) = \frac{x+1}{\sqrt{10x+8}}$  |
| 22. $g(x) = \frac{5}{1+\frac{3}{x+2}}$             | 23. $i(x) = \frac{7}{3-\frac{4}{x+1}}$   | 24. $n(x) = \frac{7x+14}{\sqrt{2x-1}}$ |
| 25. $a(x) = \frac{\frac{x}{x-2}}{\frac{3}{x-2}+6}$ | 26. $d(x) = \frac{7x-5}{\sqrt[3]{5x+2}}$ |  |

## 2.3 Answer Key

### Evaluating Functions

- |                                      |   |                          |
|--------------------------------------|---|--------------------------|
| 1. $-55$                             | 2. $-20$                                | 3. $0$                   |
| 4. $-4$                              | 5. $-5.2$                               | 6. $-1$                  |
| 7. $-3x^2 - 4x$                      | 8. $-\frac{1}{x} - 5 = \frac{-1-5x}{x}$ | 9. $-12x^2 + 8x$         |
| 10. $\frac{1-10x}{2x}$               | 11. $-3x^2 + 22x - 39$                  | 12. $\frac{16-5x}{x-3}$  |
| 13. $-\frac{1}{3}x^2 + \frac{4}{3}x$ | 14. $\frac{3-5x}{x}$                    | 15. $-12x^2 - 4x + 1$    |
| 16. $-\frac{10x+4}{2x+1}$            | 17. $-3x^2 + 38x - 119$                 | 18. $\frac{5x-34}{-x+7}$ |

### Domain of Functions

- |   |   |  |
|---|---|--|
| 1. $(-\infty, \infty)$  | 2. $[\frac{-12}{5}, \infty)$  | 3. $(-\infty, \frac{7}{9}) \cup (\frac{7}{9}, \infty)$       |
| 4. $(-\infty, \infty)$  | 5. $(-\infty, \infty)$  | 6. $(-\infty, \frac{5}{3}) \cup (\frac{5}{3}, \infty)$       |
| 7. $[4, \infty)$  | 8. $(-\infty, -4) \cup (-4, 4) \cup (4, \infty)$                          | 9. $(-\infty, -2) \cup (-2, 0) \cup (0, 2) \cup (2, \infty)$ |
| 10. $(4, \infty)$   | 11. $(-\infty, \infty)$   | 12. $(-\infty, -1) \cup (-1, 6) \cup (6, \infty)$            |
| 13. $[-\frac{3}{2}, \infty)$  | 14. $(-\infty, \infty)$   | 15. $(-\infty, -2) \cup (-2, -1) \cup (-1, \infty)$          |
| 16. $(-\infty, \frac{8}{9}]$  | 17. $(-\infty, \infty)$   | 18. $(-\infty, \infty)$                                      |
| 19. $(-3, \infty)$  | 20. $(-\infty, -\frac{67}{9}) \cup (-\frac{67}{9}, -7) \cup (-7, \infty)$ | 21. $(-\frac{4}{5}, \infty)$                                 |
| 22. $(\infty, -5) \cup (-5, -2) \cup (-2, \infty)$                  | 23. $(-\infty, -1) \cup (-1, \frac{1}{3}) \cup (\frac{1}{3}, \infty)$     | 24. $(\frac{1}{2}, \infty)$                                  |
| 25. $(-\infty, \frac{3}{2}) \cup (\frac{3}{2}, 2) \cup (2, \infty)$ | 26. $(-\infty, -\frac{2}{5}) \cup (-\frac{2}{5}, \infty)$                 |  |



# Properties of Functions

## 3.1 Maxima and Minima

Find the coordinates of the any relative maxima or minima. Round to 3 decimal places when necessary.

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

2.  $g(x) = -0.4x^3 + 0.6x^2 + 3x - 2$

3.  $f(x) = -x^4 + 3x^2 - 2x + 6$

4.  $g(x) = 0.25x^5 - 0.1x^4 + 2x^2 - 6x$

5.  $f(x) = -4x^3 + 2x^2 + 10x + 4$

6.  $g(x) = x^4 - 4x^3 + 3x^2 + 4x - 4$

7. The concentration  $C$  of a medication in the bloodstream  $t$  hours after being administered can be modeled by

$$C(t) = -0.002t^4 + 0.039t^3 - 0.285t^2 + 0.766t + 0.085, \quad t \geq 0$$

After how many hours will the concentration be the highest?

## 3.2 Increasing, Decreasing, and Constant Intervals

Find the intervals in which each is increasing or decreasing. Round to 3 decimal places when necessary.

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

2.  $g(x) = -0.4x^3 + 0.6x^2 + 3x - 2$

3.  $f(x) = x^3 + 2x^2 - 4x - 8$

4.  $g(x) = x^4 - 2x^2 + 1$

5.  $h(x) = \sqrt{x+1} - 2$

6.  $f(x) = -4x^3 + 2x^2 + 10x + 4$

7.  $g(x) = x^4 - 4x^3 + 3x^2 + 4x - 4$

### 3.3 Piecewise Functions

Find the value of each given the piecewise function below. Use exact answers when possible.

$$f(x) = \begin{cases} x^2 - 1 & \text{if } x < -3 \\ 0.2x + 7 & \text{if } -3 \leq x < 2 \\ \sqrt{5x} & \text{if } x \geq 2 \end{cases}$$

1.  $f(3)$
2.  $f(0)$
3.  $f(-2)$
4.  $f(-3)$
5.  $f(0.5)$

Find each of the following given the piecewise function

$$f(x) = \begin{cases} x^2 - 7 & x \leq -4 \\ \sqrt{2x + 7} & -4 < x < 0 \\ |-x - 1| & x \geq 0 \end{cases}$$

6.  $f(3)$
7.  $f(-2)$
8.  $f(0)$
9.  $f(-5)$

Find the value of each given the piecewise function below. Round to 3 decimal places when necessary.

$$f(x) = \begin{cases} x^2 - 5 & \text{if } x \leq -3 \\ \sqrt{-4x + 1} & \text{if } -3 < x \leq 0 \\ \frac{5x^2}{x+7} & \text{if } x > 0 \end{cases}$$

10.  $f(7)$
11.  $f(-3)$
12.  $f(1)$
13.  $f(0)$
14.  $f(-1)$
15.  $f(-3/2)$

### 3.4 Miscellaneous

Use the graph of  $y = f(x)$  below to answer the following questions. Write your answers using interval notation.



- |                           |                           |
|---------------------------|---------------------------|
| 1. Domain of $f$          | 2. Range of $f$           |
| 3. Relative Minimum       | 4. Relative Maximum       |
| 5. $f(1)$                 | 6. $f(0)$                 |
| 7. Increasing Interval(s) | 8. Decreasing Interval(s) |
| 9. Absolute Maximum       | 10. Absolute Minimum      |

Find each of the following given  $f(x) = -2x^3 + 6x^2 - 5x + 1$ . Round to 3 decimal places and use interval notation when applicable.

- |                |                |                            |                            |
|----------------|----------------|----------------------------|----------------------------|
| 11. $f(7)$     | 12. $f(-2)$    | 13. Rel. Max               | 14. Rel. Min               |
| 15. Global Max | 16. Global Min | 17. Increasing Interval(s) | 18. Decreasing Interval(s) |

Use the graph of  $f(x)$  to answer each.



- |                               |                                       |                                       |
|-------------------------------|---------------------------------------|---------------------------------------|
| 19. Relative maxima of $f(x)$ | 20. Relative minima of $f(x)$         | 21. Absolute maxima of $f(x)$         |
| 22. Absolute minima of $f(x)$ | 23. Intervals where $f$ is increasing | 24. Intervals where $f$ is decreasing |
| 25. Zeros of $f$              |                                       |                                       |

Given the labeled points A through G on the graph of  $f(x)$  below, find each of the following.



26. Increasing interval(s)

27. Decreasing interval(s)

28. Relative max

29. Relative min

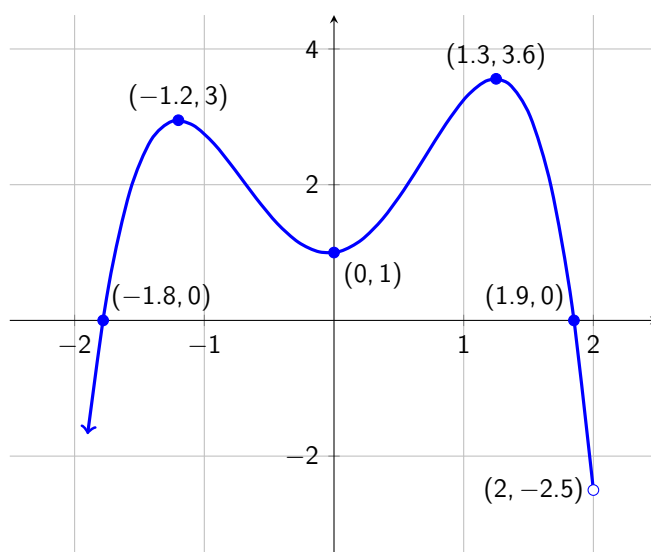
30. Global max

31. Global min

32. Zeros of  $f$

33. Number of solutions to  $f(x) = 1$

Answer each of the following about the function  $f(x)$  below.



34. Domain of  $f$

35. Range of  $f$

36. Relative maxima

37. Relative minima

38. Absolute maximum

39. Absolute minimum

40. Increasing intervals

41. Decreasing intervals

42. Zeros of  $f(x)$

43. Number of solutions to  $f(x) = 2$

## 3.5 Answer Key

### Maxima and Minima

1. Rel max @  $(0, 5)$ ; No rel min
2. Rel max @  $(2.158, 3.248)$ ; Rel min @  $(-1.158, -4.048)$
3. Rel Max  $(-1.366, 10.848)$  and  $(1, 6)$ ; Rel Min  $(0.366, 5.652)$
4. Rel Max  $(-1.716, 11.598)$ ; Rel Min  $(1.132, -3.929)$
5. Rel Max:  $(1.095, 12.096)$ ; Rel Min  $(-0.761, -0.680)$
6. Rel Max:  $(1.366, 0.348)$ ; Rel Min:  $(-0.366, -4.848)$  and  $(2, 0)$
7. About 2.16 hours

### Increasing, Decreasing, and Constant Intervals

1. Increasing:  $(-\infty, 0)$  Decreasing:  $(0, \infty)$
2. Increasing:  $(-1.158, 2.158)$  Decreasing:  $(-\infty, -1.158) \cup (2.158, \infty)$
3. Inc:  $(-\infty, -2) \cup (\frac{2}{3}, \infty)$  Dec:  $(-2, \frac{2}{3})$
4. Inc:  $(-1, 0) \cup (1, \infty)$  Dec:  $(-\infty, -1) \cup (0, 1)$
5. Inc:  $(-1, \infty)$  No intervals where it is decreasing
6. Inc:  $(-0.761, 1.095)$ ; Dec:  $(-\infty, -0.761) \cup (1.095, \infty)$
7. Inc:  $(-0.366, 1.366) \cup (2, \infty)$ ; Dec:  $(-\infty, -0.366) \cup (1.366, 2)$

### Piecewise Functions

- |                              |                              |                              |
|------------------------------|------------------------------|------------------------------|
| 1. $\sqrt{15} \approx 3.873$ | 2. 7                         | 3. 6.6                       |
| 4. 6.4                       | 5. 7.1                       | 6. 4                         |
| 7. $\sqrt{3} \approx 1.732$  | 8. 1                         | 9. 18                        |
| 10. 17.5                     | 11. 4                        | 12. $\frac{5}{8}$            |
| 13. 1                        | 14. $\sqrt{5} \approx 2.236$ | 15. $\sqrt{7} \approx 2.646$ |

## Miscellaneous

1.  $[-2, \infty)$
2.  $[-4, \infty)$
3.  $(0, -4)$
4.  $(-1, -1)$
5.  $-1$
6.  $-4)$
7.  $(-2, -1) \cup (0, \infty)$
8.  $(-1, 0)$
9.  $(0, -4)$
10. None
11.  $-426$
12.  $51$
13.  $(1.408, 0.272)$
14.  $(0.592, -0.272)$
15. None
16. None
17.  $(0.592, 1.408)$
18.  $(-\infty, 0.592) \cup (1.408, \infty)$
19.  $(b, f(b))$  and  $(m, f(m))$
20.  $(c, f(c))$
21.  $(m, f(m))$
22. None
23.  $(-\infty, b) \cup (c, m)$
24.  $(b, c) \cup (m, p)$
25.  $x = a, x = c, x = n$
26.  $(\infty, B) \cup (D, F)$
27.  $(B, D) \cup (F, \infty)$
28.  $B$  and  $F$
29.  $D$
30.  $B$
31. None
32.  $A, C, E, G$
33.  $2$
34.  $(-\infty, 2)$
35.  $(-\infty, 3.6]$
36.  $(-1.2, 3)$  and  $(1.3, 3.6)$
37.  $(0, 1)$
38.  $(1.3, 3.6)$
39. Does not exist
40.  $(-\infty, -1.2) \cup (0, 1.3)$
41.  $(-1.2, 0) \cup (1.3, 2)$
42.  $(-1.8, 0)$  and  $(1.9, 0)$
43.  $4$

# Chapter 4

## Linear Functions and Slope

### 4.1 Equations of Lines

Write the equation of each line **in point-slope form** that goes through each pair of points.

1.  $(-2, 1), (7, 8)$
2.  $(0, 4), (9, -15)$
3.  $(-1, -2), (-3, -13)$

### 4.2 Average Rate of Change

For the function  $f(x) = x^2$ , compute the average rate of change for each interval.

1.  $[1, 1.1]$
2.  $[1, 1.01]$
3.  $[1, 1.001]$
4.  $[1, 1.0001]$
5. For your answers in the previous four problems, what value do your average rates of change get closer and closer to?

Find the average rate of change of the function  $f(x) = -6x^2 + 7x + 4$  over each specified interval.

6.  $[-2, -1]$
7.  $[5, 6]$
8.  $[0, 1]$
9.  $[5, 5.001]$
10.  $[5, 5.0001]$
11.  $[5, 5.00001]$
12. What value are your last 3 answers getting closer to?

For the function  $f(x) = -3x^2 + 5$ , determine the average rate of change of each over the given interval.

13.  $[7, 7.001]$
14.  $[7, 7.0001]$
15.  $[7, 7.00001]$
16. For your answers in the previous three problems, what value do your average rates of change get closer and closer to?

Given  $f(x) = \sqrt{x}$ , find the average rate of change of each over the given interval.

17.  $[1, 1.0001]$

18.  $[1, 1.00001]$

19.  $[1, 1.000001]$

20. For your answers in the previous three problems, what value do your average rates of change get closer and closer to?

Given  $f(x) = 6\sqrt{x}$ , find the average rate of change of each over the given interval.

21.  $[25, 25.1]$

22.  $[25, 25.01]$

23.  $[25, 25.001]$

24. For your answers in the previous three problems, what value do your average rates of change get closer and closer to?

Find the average rate of change of the function  $f(x) = -7x^3 + 6\sqrt{3x} + 4$  over each interval. Round your answers to 4 decimal places.

25.  $[0, 1]$

26.  $[10, 11]$

27.  $[8, 15]$



## 4.3 Answer Key

### Equations of Lines

1.  $y - 1 = \frac{7}{9}(x + 2)$  or  $y - 8 = \frac{7}{9}(x - 7)$
2.  $y - 4 = -\frac{19}{9}(x - 0)$  or  $y + 15 = -\frac{19}{9}(x - 9)$
3.  $y + 2 = \frac{11}{2}(x + 1)$  or  $y + 13 = \frac{11}{2}(x + 3)$

### Average Rate of Change

- |                 |                 |                |
|-----------------|-----------------|----------------|
| 1. 2.1          | 2. 2.01         | 3. 2.001       |
| 4. 2.0001       | 5. 2            | 6. 25          |
| 7. -59          | 8. 1            | 9. -53.006     |
| 10. -53.0006    | 11. -53.00006   | 12. -53        |
| 13. -42.003     | 14. -42.0003    | 15. -42.00003  |
| 16. -42         | 17. -0.499988   | 18. -0.4999988 |
| 19. -0.49999988 | 20. -0.5        | 21. 0.5994     |
| 22. 0.59999     | 23. 0.6         | 24. 0.6        |
| 25. 3.3923      | 26. -2,315.3960 | 27. -2861.4492 |

# Chapter 5

## Function Transformations

Write the function for  $g(x)$  if it is the result of  $f(x)$  after the following ordered sequence of transformations.

1. (1) Vertical stretch by 3  
(2) Shift left 1 unit  
(3) Reflect across  $y$ -axis
2. (1) Horizontal compression by 2  
(2) Shift up 1 unit
3. (1) Reflect across  $x$ -axis  
(2) Vertical compression by 4  
(3) Move right 7 units

Write the function  $g(x)$  that is a result of the following ordered sequence of transformations to  $f(x) = |x|$ .

4. (1) Reflect across  $x$ -axis  
(2) Shift right 3 units  
(3) Horizontal stretch by factor of 5
5. (1) Shift down 2 units  
(2) Reflect across  $y$ -axis  
(3) Shift up 1 unit
6. (1) Horizontal compression by factor of 7  
(2) Vertical compression by factor of 4  
(3) Shift left 9 units

Given  $f(x) = \sqrt{x}$ , determine the resulting function  $g(x)$  after the following ordered sequence of transformations.

7. (1) Shift up 2 units  
(2) Horizontal stretch by 5  
(3) Shift left 3 units
8. (1) Vertical compression by factor of 3  
(2) Reflect across  $y$ -axis  
(3) Horizontal compression by 5
9. (1) Shift right 8 units  
(2) Reflect across  $x$ -axis  
(3) Horizontal compression by factor of 4

Write the final equation of  $g(x)$  if it is found by taking  $f(x) = \sqrt{x}$  after the following ordered sequence of transformations.

10. (1) Shift right 2 units  
(2) Horizontal stretch by factor 3  
(3) Shift down 2 units  
(4) Reflect across  $x$ -axis
11. (1) Horizontal stretch by factor 3  
(2) Shift left 1 unit  
(3) Shift up 2 units  
(4) Reflect across  $y$ -axis
12. (1) Vertical stretch by factor 5  
(2) Horizontal stretch by factor 2  
(3) Shift up 3 units  
(4) Reflect across  $x$ -axis

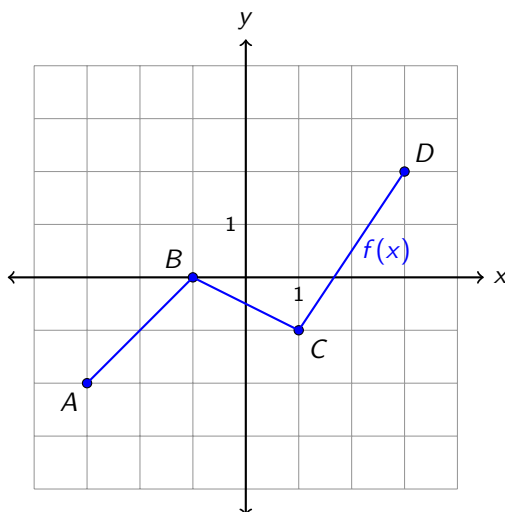
Find the equation for  $g(x)$  if  $g(x)$  is found by performing the following *ordered* sequence of transformations to  $f(x) = \frac{1}{x}$ .

13. (1) Shift left 3 spaces  
(2) Reflect across  $y$ -axis  
(3) Shift down 5 spaces  
(4) Vertical stretch by factor of 7
14. (1) Shift up 3 spaces  
(2) Reflect across  $x$ -axis  
(3) Shift right 5 spaces  
(4) Horizontal compression by factor of 7

Given  $f(x) = x^3$ , determine the equation for  $g(x)$  after the following *ordered* sequence of transformations to  $f(x)$ .

15. (1) Vertical stretch by factor of 4  
(2) Shift up 3 units  
(3) Reflect across  $y$ -axis  
(4) Shift down 5 units
16. (1) Horizontal compression by factor of 3  
(2) Shift right 4 units  
(3) Shift up 1 unit
17. (1) Reflect across  $x$ -axis  
(2) Shift down 5 units  
(3) Vertical compression by factor of 5  
(4) Horizontal stretch by factor of 9

Given the graph of  $f(x)$  below, find the new coordinates of each point after the following transformations.



18.  $-2f(x+1)$

19.  $f\left(-\frac{1}{2}x\right) - 3$

20.  $\frac{1}{2}f(-x-2) + 2$

21.  $f(2x+2) - 1$

22.  $-3f(-x+1) + 2$

23.  $5f\left(-\frac{1}{2}x\right)$

## 5.1 Answer Key

1.  $g(x) = 3f(-x + 1)$
2.  $g(x) = f(2x) + 1$
3.  $g(x) = -\frac{1}{4}f(x - 7)$
4.  $g(x) = -\left|\frac{1}{5}x - 3\right|$
5.  $g(x) = |-x| - 1$
6.  $g(x) = \frac{1}{4}|7(x + 9)| = \frac{1}{4}|7x + 63|$
7.  $g(x) = \sqrt{\frac{1}{5}(x + 3)} + 2 = \sqrt{\frac{1}{5}x + \frac{3}{5}} + 2$
8.  $g(x) = \frac{1}{3}\sqrt{-5x}$
9.  $g(x) = -\sqrt{4x - 8}$
10.  $g(x) = -\left(\sqrt{\frac{1}{3}x - 2} - 2\right) = -\sqrt{\frac{1}{3}x - 2} + 2$
11.  $g(x) = \sqrt{\frac{1}{3}(-x + 1)} + 2 = \sqrt{-\frac{1}{3}x + \frac{1}{3}} + 2$
12.  $g(x) = -\left(5\sqrt{\frac{1}{2}x + 3}\right) = -5\sqrt{\frac{1}{2}x + 3}$
13.  $g(x) = \frac{7}{-x+3} - 35$
14.  $g(x) = -\frac{1}{7x-5} - 3$
15.  $g(x) = 4(-x)^3 - 2$
16.  $g(x) = (3(x - 4))^3 + 1$
17.  $g(x) = \frac{1}{5}\left(-\frac{1}{9}x\right)^3 - 5$
18.  $A'(-4, 4), B'(-2, 0), C'(0, 2), D'(2, -4)$
19.  $A'(6, -5), B'(2, -3), C'(-2, -4), D'(-6, -1)$
20.  $A'(1, 1), B'(-1, 2), C'(-3, 1.5), D'(-5, 3)$
21.  $A'(-2.5, -3), B'(-1.5, -1), C'(-0.5, -2), D'(0.5, 1)$
22.  $A'(4, 8), B'(2, 2), C'(0, 5), D'(-2, -4)$
23.  $A'(6, -10), B'(2, 0), C'(-2, -5), D'(-6, 10)$

# Chapter 6

## Function Operations

### 6.1 Adding, Subtracting, Multiplying, and Dividing Functions

Given  $f(x) = x + 5$ ,  $g(x) = x^2 - 1$ , and  $h(x) = \sqrt{x - 10}$ , simplify or evaluate each.

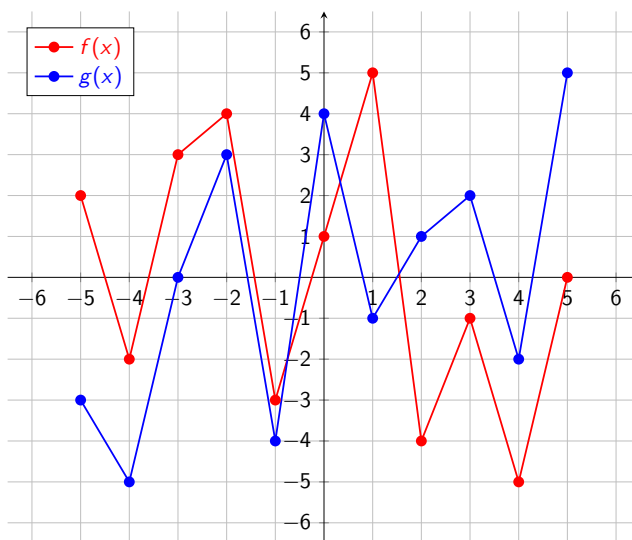
1.  $(g - f)(x)$
2.  $(fh)(14)$
3.  $(f + g)(x)$

Find each of the following given the table below.

x	-4	-3	-2	-1	0	1	2	3	4
f(x)	-3	0	-1	3	1	2	4	-4	-2
g(x)	3	-1	0	1	4	-2	-4	2	-3

4.  $(f + g)(-2)$
5.  $(f - g)(0)$
6.  $(fg)(1)$
7.  $\left(\frac{f}{g}\right)(3)$
8.  $(f + f)(-4)$

Find each of the following given the graphs of  $f(x)$  (in red) and  $g(x)$  (in blue) below:



9.  $(f + g)(2)$
10.  $(f - g)(1)$
11.  $(g - f)(-3)$
12.  $(fg)(4)$
13.  $\left(\frac{f}{g}\right)(0)$

Use the table below to find each.

$x$	-5	-4	-3	-2	-1	0	1	2	3	4	5
$f(x)$	-1	3	-4	5	0	4	-5	2	-2	-3	1
$g(x)$	4	-2	-4	1	-1	3	0	-3	-5	2	5

14.  $(f + g)(-1)$       15.  $(f - g)(2)$       16.  $(fg)(-3)$       17.  $\left(\frac{f}{g}\right)(5)$       18.  $(ff)(-4)$

## 6.2 Operations with Functions: Domain

Given  $f(x) = \sqrt{2x+7}$  and  $g(x) = 3x+3$ , find the domain of each.

- $(f + g)(x)$
- $\left(\frac{f}{g}\right)(x)$
- $\left(\frac{g}{f}\right)(x)$

## 6.3 Difference Quotient

Write the difference quotient for each.

- $f(x) = 2x - 7$
- $g(x) = x^2 + 4x$
- $h(x) = -1$
- $f(x) = \frac{3}{x+2}$
- $g(x) = \sqrt{3x}$
- $f(x) = x^2 - 2x + 5$
- $g(x) = \frac{5}{x}$
- $f(x) = -2x^2 + 3x - 5$
- $g(x) = \frac{6}{2x+3}$
- $h(x) = \sqrt{7x+5}$
- $f(x) = -x^2 + x$
- $f(x) = 3x - 1$
- $f(x) = x^3 + 5x$
- $f(x) = \frac{6}{x+7}$
- $g(x) = \frac{9}{x}$
- $h(x) = \frac{5}{2x-1}$

## 6.4 Answer Key

### Adding, Subtracting, Multiplying, and Dividing Functions

- |                  |                   |
|------------------|-------------------|
| 1. $x^2 - x - 6$ | 10. 6             |
| 2. 38            | 11. $-3$          |
| 3. $x^2 + x + 4$ | 12. 10            |
| 4. $-1$          | 13. $\frac{1}{4}$ |
| 5. $-3$          | 14. $-1$          |
| 6. $-4$          | 15. 5             |
| 7. $-2$          | 16. 16            |
| 8. $-6$          | 17. $\frac{1}{5}$ |
| 9. $-3$          | 18. 9             |

### Operations with Functions: Domain

- $[-\frac{7}{2}, \infty)$
- $[-\frac{7}{2}, -1) \cup (-1, \infty)$
- $(-\frac{7}{2}, \infty)$

### Difference Quotient

- |  |                                       |                                  |
|--|---------------------------------------|----------------------------------|
| 1. 2                                       | 2. $2x + h + 4$                       | 3. 0                             |
| 4. $\frac{-3}{(x+2)(x+h+2)}$               | 5. $\frac{3}{\sqrt{3x+3h}+\sqrt{3x}}$ | 6. $2x + h - 2$                  |
| 7. $\frac{-5}{x(x+h)}$                     | 8. $-4x - 2h + 3$                     | 9. $\frac{-12}{(2x+3)(2x+2h+3)}$ |
| 10. $\frac{7}{\sqrt{7x+7h+5}+\sqrt{7x+5}}$ | 11. $-2x - h + 1$                     | 12. 3                            |
| 13. $3x^2 + 3xh + h^2 + 5$                 | 14. $\frac{-6}{(x+7)(x+h+7)}$         | 15. $\frac{-9}{x(x+h)}$          |
| 16. $\frac{-10}{(2x-1)(2x+2h-1)}$          |                                       |                                  |



# Chapter 7

## Polynomials and Their Graphs

Find the degree, leading term, leading coefficient, and constant term of the following polynomials.

1.  $f(x) = -x^5 + \sqrt{7}x^3 - 2x^2$

2.  $g(x) = 4x^2 - 16x^6 + 3x$

3.  $h(x) = 1 + x^{11} - 4x^8$

4.  $f(x) = -x^4 + 3x^2 - 2x + 6$

5.  $g(x) = 0.25x^5 - 0.1x^4 + 2x^2 - 6x$

6.  $f(x) = -6x^3 + 2x^2 + 7x^4 - 1$

7.  $g(x) = \frac{1}{3}x^3 - \frac{\pi}{8}x^2 + x\sqrt{2} - 3^4$

8.  $h(x) = 7(x+1)^2(x-2)^3$

9.  $j(x) = -\frac{1}{2}(3x+2)^2(x-1)^5$

Determine the end behavior of each.

10.  $f(x) = -x^5 + \sqrt{7}x^3 - 2x^2$

11.  $g(x) = 4x^2 - 16x^6 + 3x$

12.  $h(x) = 1 + x^{11} - 4x^8$

13.  $f(x) = -x^4 + 3x^2 - 2x + 6$

14.  $g(x) = 0.25x^5 - 0.1x^4 + 2x^2 - 6x$

15.  $f(x) = -6x^3 + 2x^2 + 7x^4 - 1$

16.  $g(x) = \frac{1}{3}x^3 - \frac{\pi}{8}x^2 + x\sqrt{2} - 3^4$

17.  $h(x) = 5(x+1)^2(x-2)^3$

18.  $j(x) = -\frac{1}{2}(3x+2)^2(x-1)^5$

Find the zeros of each. Round to 2 decimal places when necessary.

19.  $f(x) = -x^5 + \sqrt{7}x^3 - 2x^2$

20.  $g(x) = 4x^2 - 16x^6 + 3x$

21.  $h(x) = 1 + x^{11} - 4x^8$

22.  $f(x) = -x^4 + 3x^2 - 2x + 6$

23.  $g(x) = 0.25x^5 - 0.1x^4 + 2x^2 - 6x$

24.  $f(x) = -6x^3 + 2x^2 + 7x^4 - 1$

25.  $g(x) = \frac{1}{3}x^3 - \frac{\pi}{8}x^2 + x\sqrt{2} - 3^4$

26.  $h(x) = 5(x+1)^2(x-2)^3$

27.  $j(x) = -\frac{1}{2}(3x+2)^2(x-1)^5$

## 7.1 Answer Key

1. Degree = 5, Leading Term =  $-x^5$ , Leading Coefficient =  $-1$ , Constant = none (or 0)
2. Degree = 6, Leading Term =  $-16x^6$ , Leading Coefficient =  $-16$ , Constant = none (or 0)
3. Degree = 11, Leading Term =  $x^{11}$ , Leading Coefficient = 1, Constant = 1
4. Degree = 4, Leading Term =  $-x^4$ , Leading Coefficient =  $-1$ , Constant = 6
5. Degree = 5, Leading Term =  $0.25x^5$ , Leading Coefficient = 0.25, Constant = none (or 0)
6. Degree = 3, Leading Term =  $-6x^3$ , Leading Coefficient =  $-6$ , Constant =  $-1$
7. Degree = 3, Leading Term =  $\frac{1}{3}x^3$ , Leading Coefficient =  $\frac{1}{3}$ , Constant =  $3^4$
8. Degree = 5, Leading Term =  $7x^5$ , Leading Coefficient = 7, Constant =  $-56$
9. Degree = 7, Leading Term =  $-\frac{9}{2}x^7$ , Leading Coefficient =  $-\frac{9}{2}$ , Constant = 2
10.  $\lim_{x \rightarrow -\infty} f(x) = \infty$      $\lim_{x \rightarrow \infty} f(x) = -\infty$
11.  $\lim_{x \rightarrow -\infty} g(x) = -\infty$ ,     $\lim_{x \rightarrow \infty} g(x) = \infty$
12.  $\lim_{x \rightarrow -\infty} h(x) = -\infty$      $\lim_{x \rightarrow \infty} h(x) = \infty$
13.  $\lim_{x \rightarrow -\infty} f(x) = -\infty$      $\lim_{x \rightarrow \infty} f(x) = -\infty$
14.  $\lim_{x \rightarrow -\infty} g(x) = -\infty$      $\lim_{x \rightarrow \infty} g(x) = \infty$
15.  $\lim_{x \rightarrow -\infty} f(x) = \infty$      $\lim_{x \rightarrow \infty} f(x) = -\infty$
16.  $\lim_{x \rightarrow -\infty} g(x) = -\infty$      $\lim_{x \rightarrow \infty} g(x) = \infty$
17.  $\lim_{x \rightarrow -\infty} h(x) = -\infty$      $\lim_{x \rightarrow \infty} h(x) = \infty$
18.  $\lim_{x \rightarrow -\infty} j(x) = \infty$      $\lim_{x \rightarrow \infty} j(x) = -\infty$
19.  $(-1.92, 0)$ ,  $(0, 0)$
20.  $(0, 0)$ ,  $(0.83, 0)$
21.  $(-0.83, 0)$ ,  $(0.86, 0)$ ,  $(1.58, 0)$
22.  $(-2.25, 0)$ ,  $(1.90, 0)$
23.  $(-2.48, 0)$ ,  $(0, 0)$ ,  $(1.85, 0)$
24.  $(-0.42, 0)$ ,  $(0.79, 0)$
25.  $(6.42, 0)$
26.  $(-1, 0)$ ,  $(2, 0)$
27.  $(-\frac{2}{3}, 0)$ ,  $(1, 0)$

# Dividing Polynomials

## 8.1 Dividing Polynomials

Divide each.

1.  $(28x^3 - 26x^2 + 41x - 15) \div (7x - 3)$
2.  $(44y^2 + 12y^3 + 61y - 37) \div (3y + 5)$
3.  $(4x^3 - 3x^2 + x + 1) \div (x + 2)$
4.  $(5x^4 - x^2 + x - 2) \div (x^2 + 2)$
5.  $(10x^3 + 27x^2 + 8x - 11) \div (2x + 3)$
6.  $(7x^3 + 23x^2 + 12x + 1) \div (x^2 + 3x + 1)$
7.  $(28x^3 - 27x^2 - 4x + 17) \div (4x + 3)$
8.  $(7x^3 - 27x + 4) \div (x^2 - 5)$
9.  $(11x^6 - 24x^5 + 15x^4 - 19x^3 - 16x^2 + 21x - 8) \div (x - 2)$
10.  $(12x^5 - 15x^4 - 11x^3 + 16x^2 - 15x + 17) \div (3x^2 - 5)$
11.  $(6x^4 + 20x^3 - 13x^2 + 20x + 25) \div (x + 4)$
12.  $(24x^5 + 30x^4 - 21x^3 - 4x^2 + 3x - 25) \div (6x^3 + 3x^2 + 3)$
13.  $(3x^5 - 22x^4 + 12x^3 + 10x^2 - 7x + 24) \div (3x^2 - x - 4)$
14.  $(3x^4 - 23x^2 - 15x^3 + 28x + 24) \div (x - 6)$
15.  $(-29x^2 + 6x^6 - 29x^3 + 25x^4 - 15x^5 - 25 - 29x) \div (3x^3 - 6x^2 - 3 - x)$
16.  $(12x^6 + 16x^5 - 5x^4 + 12x^3 - 17x^2 - x - 23) \div (x + 2)$

## 8.2 Remainder and Factor Theorems

Determine the remainder of each.

1.  $(2x^{53} - 9x^{44} + 13x^8) \div (x - 1)$
2.  $(x^{71} + 15x^{58} - 3x^{14} + 2) \div (x + 1)$
3.  $(x^{23} - 5x^{20} + 17x^8 - 5) \div (x + 2)$
4.  $(-7x^{17} + 40x^{15} - 6x^8 + 4x^3) \div (x - 3)$

## 8.3 Answer Key

### Dividing Polynomials

1.  $4x^2 - 2x + 5$
2.  $4y^2 + 8y + 7 - \frac{72}{3y+5}$
3.  $4x^2 - 11x + 23 - \frac{45}{x+2}$
4.  $5x^2 - 11 + \frac{x+20}{x^2+2}$
5.  $5x^2 + 6x - 5 + \frac{4}{2x+3}$
6.  $7x + 2 + \frac{-x-1}{x^2+3x+1}$
7.  $7x^2 - 12x + 8 - \frac{7}{4x+3}$
8.  $7x + \frac{8x+4}{x^2-5}$
9.  $11x^5 - 2x^4 + 11x^3 + 3x^2 - 10x + 1 - \frac{6}{x-2}$
10.  $4x^3 - 5x^2 + 3x - 3 + \frac{2}{3x^2-5}$
11.  $6x^3 - 4x^2 + 3x + 8 - \frac{7}{x+4}$
12.  $4x^2 + 3x - 5 + \frac{-x^2-6x-10}{6x^3+3x^2+3}$
13.  $x^3 - 7x^2 + 3x - 5 + \frac{4}{3x^2-x-4}$
14.  $3x^3 + 3x^2 - 5x - 2 + \frac{12}{x-6}$
15.  $2x^3 - x^2 + 7x + 6 + \frac{11x^2-2x-7}{3x^3-6x^2-3-x}$
16.  $12x^5 - 8x^4 + 11x^3 - 10x^2 + 3x - 7 - \frac{9}{x+2}$

### Remainder and Factor Theorems

1. 6
2. 13
3. -13, 627, 141
4. -330, 064, 119

# Chapter 9

## Rational Functions and Their Graphs

Find the domain, coordinates of any holes, and equations of all asymptotes.

1.  $f(x) = \frac{2x^2+5x-3}{2x^2-15x+7}$

2.  $g(x) = \frac{3x^3+7x^2-20x}{x^2-x-12}$

3.  $f(x) = \frac{3x}{x+4}$

4.  $g(x) = \frac{x^2+3x+2}{x-1}$

5.  $h(x) = \frac{x^2+3x-4}{x^3-2x^2+x}$

6.  $f(x) = \frac{2x^3-13x^2+6x+45}{x^2-4x-5}$

7.  $g(x) = \frac{5x^2-19x-4}{x^3+2x^2-24x}$

8.  $h(x) = \frac{2x^2-x-3}{8x^2+51x+18}$

9.  $f(x) = \frac{6x^3-21x^2-51x+30}{3x^2+7x+2}$

10.  $g(x) = \frac{10x^2-29x-21}{10x^3-33x^2-7x}$

11.  $f(x) = \frac{x^3+x^2-6x}{3x^2-3x-6}$

12.  $f(x) = \frac{x^2-4x+3}{2x^2+2x-12}$

13.  $f(x) = \frac{x-4}{-2x^2+4x+16}$

14.  $f(x) = \frac{x^3-2x^2-8x}{x^3-2x^2-3x}$

15.  $f(x) = \frac{x^2+x-2}{3x^2+3x-18}$

16.  $f(x) = \frac{x^2-3x+2}{4x^2-12x}$

17.  $f(x) = \frac{8x^2+26x+15}{2x^2-x-15}$

18.  $g(x) = \frac{x^2-1}{2+2x}$

State the end behavior of each.

19.  $k(x) = \frac{5x^3-7x^2+8}{-3x^3+6x-4}$

20.  $m(x) = \frac{2x-1}{3x^2+7x+1}$

Answer each of the following given  $h(x) = \frac{6x^3+40x^2-14x}{3x^2+11x-4}$

21. End behavior

22. Domain of  $h$

23. Equation(s) for any vertical asymptotes

24. Exact coordinates of any holes

25. What is the approximate value of  $h(5^{933})$ ?

## 9.1 Answer Key

1. Domain:  $x \neq \frac{1}{2}, 7$ ; V.A.:  $x = \frac{1}{2}, x = 7$ ; H.A.:  $y = 1$
2. Domain:  $x \neq -3, 4$ ; V.A.:  $x = -3, x = 4$ ; Obl. Asymp:  $y = 3x + 10$
3. Domain:  $x \neq -4$ ; V.A.:  $x = -4$ ; H.A.:  $y = 3$
4. Domain:  $x \neq 1$ ; V.A.:  $x = 1$ ; Obl. Asymp:  $y = x + 4$
5. Domain:  $x \neq 0, 1$ ; V.A.:  $x = 0$  and  $x = 1$ ; H.A.:  $y = 0$
6. Domain:  $x \neq -1, 5$ ; V.A.  $x = -1$ ; Hole @  $(5, \frac{13}{3})$ ; Obl. Asym  $y = 2x - 5$
7. Domain:  $x \neq -6, 0, 4$ ; V.A.  $x = -6, x = 0$ ; Hole @  $(4, \frac{21}{40})$ ; H.A.  $y = 0$
8. Domain:  $x \neq -6, -\frac{3}{8}$ ; V.A.  $x = -6, x = -\frac{3}{8}$ ; H.A.  $y = \frac{1}{4}$
9. Domain:  $x \neq -2, -\frac{1}{3}$ ; Hole @  $(-2, -21)$ ; V.A.:  $x = -\frac{1}{3}$ ; Obl. Asymp:  $y = 2x - \frac{35}{3}$
10. Domain:  $x \neq -\frac{1}{5}, 0, \frac{7}{2}$ ; Hole @  $(\frac{7}{2}, \frac{82}{259})$ ; V.A.  $x = -\frac{1}{5}$  and  $x = 0$ ; H.A.  $y = 0$
11. Domain:  $x \neq -1, 2$ ; V.A.  $x = -1$ ; Hole @  $(2, \frac{10}{9})$ ; Obl. Asymp:  $y = \frac{1}{3}x + \frac{2}{3}$
12. Domain:  $x \neq -3, 2$ ; V.A.  $x = -3$  and  $x = 2$ ; H.A.  $y = \frac{1}{2}$
13. Domain:  $x \neq -2, 4$ ; V.A.  $x = 2$ ; Hole @  $(4, -\frac{1}{12})$ ; H.A.  $y = 0$
14. Domain:  $x \neq -1, 0, 3$ ; V.A.  $x = -1$  and  $x = 3$ ; Hole @  $(0, \frac{8}{3})$ ; H.A.  $y = 1$
15. Domain:  $x \neq -3, 2$ ; V.A.  $x = -3$  and  $x = 2$ ; H.A.  $y = \frac{1}{3}$
16. Domain:  $x \neq 0, 3$ ; V.A.  $x = 0$  and  $x = 3$ ; H.A.  $y = \frac{1}{4}$
17. Domain:  $x \neq -\frac{5}{2}, 3$ ; V.A.  $x = 3$ ; Hole @  $(-\frac{5}{2}, \frac{14}{11})$ ; H.A.  $y = 4$
18. Domain:  $x \neq -1$ ; No vertical asymptote; Hole @  $(-1, -1)$ ; Obl. Asymp:  $y = \frac{1}{2}x - \frac{1}{2}$
19.  $\lim_{x \rightarrow -\infty} k(x) = \infty = \lim_{x \rightarrow \infty} k(x) = -\frac{5}{3}$
20.  $\lim_{x \rightarrow -\infty} m(x) = \infty = \lim_{x \rightarrow \infty} m(x) = 0$
21.  $y = 2x + 6$
22.  $x \neq -4, \frac{1}{3}$
23.  $x = -4$
24.  $(\frac{1}{3}, \frac{44}{39})$
25.  $2(5^{933}) + 6$

# Chapter 10

## Polynomial and Rational Inequalities

### 10.1 Polynomial Inequalities

Solve each. Write your answers using interval notation.

1.  $6x^3 - 4x^2 - 10x \geq 0$
2.  $x^4 < 9x^2$
3.  $3x^3 - 7x^2 - 22x + 8 < 0$
4.  $3x^2 - 4x + 1 \leq 0$
5.  $12x^4 + 76x^3 + 43x^2 - 346x - 280 \geq 0$
6.  $-2x^4 + 49x^2 + 21x^3 - 1029x + 2401 \geq 0$
7.  $-x^2 - 7x - 6 \leq 0$
8.  $x^2 + 4x + 4 < 0$
9.  $-x^4 - 6x^3 + 61x^2 + 234x - 1008 \geq 0$
10.  $-x^2 + 3x + 1 > 3$
11.  $-3x^4 + 123x^3 + 142x^2 - 424x + 320 \leq 122x^3$
12.  $-x^4 - 1120 + 77x^2 - 36x + 15x^3 \geq 15x^3$
13.  $-3x^4 - 22x^3 + 271x^2 + 152x - 96 \geq 267x^2$
14.  $15x^3 + 27x^2 + 8x \leq 14x$
13.  $x^3 + 6x^2 > -2x^2 + 64x + 512$

### 10.2 Domain

State the domain of each. Write your answers using interval notation.

1.  $b(x) = \sqrt{21x^2 - 23x - 20}$
2.  $f(x) = \frac{3}{\sqrt{3x^2 + 2x - 1}}$
3.  $g(x) = \sqrt[4]{2x^3 + 9x^2 + 12x + 4}$

### 10.3 Rational Inequalities

Solve each. Write your answers using interval notation.

1.  $\frac{3x-4}{x+1} < 0$
2.  $\frac{x^2+3x+2}{x-7} \leq 0$
3.  $\frac{x^2-4x+4}{x^2-1} \geq 0$
4.  $\frac{x+2}{x-4} \leq 1$
5.  $\frac{x^2-7x-8}{x^2-4x-32} \geq 0$
6.  $\frac{4+3x}{5-x} \leq 2$
7.  $\frac{x-4}{x+7} < 0$
8.  $\frac{x+5}{x+7} < 0$
9.  $\frac{2x-26}{5x+20} > -3$

$$10. \frac{2x-50}{5x+15} \leq -1$$

$$13. -\frac{3}{x+6} > -\frac{4}{x+7}$$

$$16. \frac{6x^2+5x-21}{x-4} < 0$$

$$11. \frac{x+5}{x^2-2x-15} \leq 0$$

$$14. \frac{2x^2+3x-2}{x^2+5x+6} < 0$$

$$17. \frac{2x+1}{4x-3} \geq x-1$$

$$12. -\frac{2}{x} \geq -\frac{3}{x+1}$$

$$15. \frac{x-4}{2x+4} \geq 1$$



## 10.4 Answer Key

### Polynomial Inequalities

1.  $[-1, 0] \cup [\frac{5}{3}, \infty)$
2.  $(-3, 0) \cup (0, 3)$
3.  $(-\infty, -2) \cup (\frac{1}{3}, 4)$
4.  $[\frac{1}{3}, 1]$
5.  $(-\infty, -4] \cup [-\frac{7}{2}, -\frac{5}{6}] \cup [2, \infty)$
6.  $[-7, \frac{7}{2}] \cup 7$
7.  $(-\infty, -6] \cup [-1, \infty)$
8.  $\emptyset$
9.  $[-8, -7] \cup [3, 6]$
10.  $(1, 2)$
11.  $(-\infty, -8] \cup [\frac{4}{3}, 2] \cup [5, \infty)$
12.  $[-8, -4] \cup [5, 7]$
13.  $[-6, -4] \cup [\frac{2}{3}, 2]$
14.  $(-\infty, -2] \cup [0, \frac{1}{5}]$
15.  $(8, \infty)$

### Domain

1.  $(-\infty, -\frac{12}{21}] \cup [\frac{5}{3}, \infty)$
2.  $(-\infty, -1) \cup (\frac{1}{3}, \infty)$
3.  $\{-2\} \cup [-\frac{1}{2}, \infty)$

### Rational Inequalities

1.  $(-1, \frac{4}{3})$
2.  $(-\infty, -2] \cup [-1, 7)$
3.  $(-\infty, -1) \cup (1, \infty)$
4.  $(-\infty, 4)$
5.  $(-\infty, -4) \cup [-1, 8) \cup (8, \infty)$
6.  $(-\infty, 1.2] \cup (5, \infty)$
7.  $(-7, 4)$
8.  $(-7, -5)$
9.  $(-\infty, -4) \cup (-2, \infty)$
10.  $(-3, 5]$
11.  $(-\infty, -5] \cup (-3, 5)$
12.  $(-1, 0) \cup [2, \infty)$
13.  $(-7, -6) \cup (-3, \infty)$
14.  $(-3, -2) \cup (-2, \frac{1}{2})$
15.  $[-8, -2)$
16.  $(-\infty, -\frac{7}{3}) \cup (\frac{3}{2}, 4)$
17.  $(-\infty, \frac{1}{4}] \cup (\frac{3}{4}, 2]$

# Chapter 11

## Function Compositions

Given  $f(x) = x - 5$ ,  $g(x) = 4 + \sqrt{2x + 1}$ , and  $h(x) = \frac{3}{x + 7}$ , simplify each and state the domain.

1.  $(f \circ g)(x)$
2.  $(g \circ f)(x)$
3.  $h(h(x))$

Find each of the following given the table below.

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

4.  $(f \circ g)(-1)$
5.  $(g \circ g)(0)$
6.  $(f \circ f)(2)$
7.  $(g \circ g)(-3)$
8.  $f(g(0))$

Use the table below to answer each.

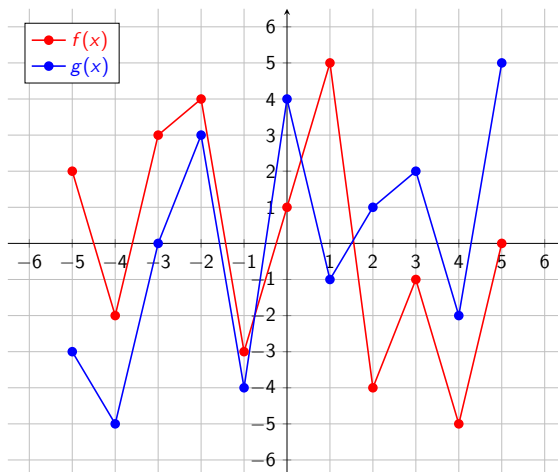
$x$	-4	-3	-2	-1	0	1	2	3	4
$f(x)$	1	-1	-2	4	0	-4	-3	3	2
$g(x)$	0	-2	1	-4	-3	2	-1	4	3

9.  $(f \circ g)(-1)$
10.  $f(g(3))$
11.  $(g \circ f)(0)$
12.  $f(f(4))$
13.  $g(f(g(1)))$

Given  $f(x) = \sqrt{3x + 2}$ ,  $g(x) = x^2 - 1$ , and  $h(x) = 9x - 2$ , find each of the following.

14.  $(g \circ f)(x)$
15.  $f(g(x))$
16.  $(h \circ h)(x)$

Find each of the following given the graphs of  $f(x)$  (in red) and  $g(x)$  (in blue) below:



17.  $(f \circ g)(-1)$

18.  $(g \circ f)(-4)$

19.  $f(g(3))$

20.  $g(g(-2))$

21.  $(f \circ f)(-5)$

Given  $f(x) = \sqrt{2x-9}$  and  $g(x) = \frac{2x}{x-3}$ , simplify each and state the domain of the composition.

22.  $f(g(x))$

23.  $(g \circ f)(x)$

24.  $g(g(x))$

## 11.1 Answer Key

1.  $-1 + \sqrt{2x + 1}$  Domain:  $[-\frac{1}{2}, \infty)$
2.  $4 + \sqrt{2x - 9}$  Domain:  $[\frac{9}{2}, \infty)$
3.  $\frac{3x+21}{7x+52}$  Domain:  $(-\infty, -\frac{52}{7}) \cup (-\frac{52}{7}, -7) \cup (-7, \infty)$
4. 2
5. -3
6. -2
7. 1
8. -2
9. 1
10. 2
11. -3
12. -3
13. -2
14.  $3x + 1$
15.  $\sqrt{3x^2 - 1}$
16.  $81x - 20$
17. -2
18. 3
19. -4
20. 2
21. -4
22.  $f(g(x)) = \sqrt{\frac{-5x+27}{x-3}}; \quad (3, \frac{27}{5}]$
23.  $(g \circ f)(x) = \frac{2\sqrt{2x-9}}{\sqrt{2x-9}-3}; \quad [\frac{9}{2}, 9) \cup (9, \infty)$
24.  $g(g(x)) = \frac{4x}{9-x}; \quad (-\infty, 3) \cup (3, 9) \cup (9, \infty)$

# Chapter 12

## Inverse Functions

Find the inverse of each. Then state the domain and range of the function and the inverse.

1.  $f(x) = \sqrt{-2x+3} + 1$

2.  $g(x) = (x+4)^2 - 1, x \leq -4$

3.  $h(x) = \frac{9x}{4x-1}$

4.  $f(x) = \sqrt{x} - 3$

5.  $g(x) = \frac{1}{1-x}$

6.  $h(x) = x^2 + 6x + 4, x \leq -3$

7.  $f(x) = \sqrt{5x-4}$

8.  $g(x) = x^2 - 2x + 3, x \leq 1$

9.  $h(x) = \frac{3}{x-1}$

10.  $f(x) = 5 - \sqrt{2x}$

11.  $g(x) = \frac{5}{x+1}$

12.  $h(x) = \frac{3x}{x-2}$

## 12.1 Answer Key

1.  $f^{-1}(x) = -\frac{1}{2}((x-1)^2 - 3)$

	Domain	Range
$f(x)$	$(-\infty, 1.5]$	$[1, \infty)$
$f^{-1}(x)$	$[1, \infty)$	$(-\infty, 1.5]$

2.  $g^{-1}(x) = -\sqrt{x+1} - 4$

	Domain	Range
$g(x)$	$(-\infty, -4]$	$[-1, \infty)$
$g^{-1}(x)$	$[-1, \infty)$	$(-\infty, -4]$

3.  $h^{-1}(x) = \frac{-x}{9-4x}$

	Domain	Range
$h(x)$	$(-\infty, 1/4) \cup (1/4, \infty)$	$(\infty, 9/4) \cup (9/4, \infty)$
$h^{-1}(x)$	$(\infty, 9/4) \cup (9/4, \infty)$	$(-\infty, 1/4) \cup (1/4, \infty)$

4.  $f^{-1}(x) = (x+3)^2$

	Dom	Ran
$f(x)$	$[0, \infty)$	$[-3, \infty)$
$f^{-1}(x)$	$[-3, \infty)$	$[0, \infty)$

5.  $g^{-1}(x) = 1 - \frac{1}{x}$

	Dom	Ran
$g(x)$	$(-\infty, 1) \cup (1, \infty)$	$(-\infty, 0) \cup (0, \infty)$
$g^{-1}(x)$	$(-\infty, 0) \cup (0, \infty)$	$(-\infty, 1) \cup (1, \infty)$

6.  $h^{-1}(x) = -\sqrt{x+5} - 3$

	Dom	Ran
$h(x)$	$(-\infty, -3]$	$[-5, \infty)$
$h^{-1}(x)$	$[-5, \infty)$	$(-\infty, -3]$

7.  $f^{-1}(x) = \frac{1}{5}x^2 + \frac{4}{5}$

	Dom	Ran
$f(x)$	$[\frac{4}{5}, \infty)$	$[0, \infty)$
$f^{-1}(x)$	$[0, \infty)$	$[\frac{4}{5}, \infty)$

8.  $g^{-1}(x) = -\sqrt{x-2} + 1$

	Dom	Ran
$g(x)$	$(-\infty, 1]$	$[2, \infty)$
$g^{-1}(x)$	$[2, \infty)$	$(-\infty, 1]$

9.  $h^{-1}(x) = \frac{3}{x} + 1$

	Dom	Ran
$h(x)$	$(-\infty, 1) \cup (1, \infty)$	$(-\infty, 0) \cup (0, \infty)$
$h^{-1}(x)$	$(-\infty, 0) \cup (0, \infty)$	$(-\infty, 1) \cup (1, \infty)$

10.  $f^{-1}(x) = \frac{1}{2}(x - 5)^2; x \leq 5$

	Domain	Range
$f(x)$	$[0, \infty)$	$(-\infty, 5]$
$f^{-1}(x)$	$(-\infty, 5]$	$[0, \infty)$

11.  $g^{-1}(x) = \frac{5}{x} - 1$

	Domain	Range
$g(x)$	$(-\infty, -1) \cup (-1, \infty)$	$(-\infty, 0) \cup (0, \infty)$
$g^{-1}(x)$	$(-\infty, 0) \cup (0, \infty)$	$(-\infty, -1) \cup (-1, \infty)$

12.  $h^{-1}(x) = \frac{2x}{x-3}$

	Domain	Range
$h(x)$	$(-\infty, 2) \cup (2, \infty)$	$(-\infty, 3) \cup (3, \infty)$
$h^{-1}(x)$	$(-\infty, 3) \cup (3, \infty)$	$(-\infty, 2) \cup (2, \infty)$

# Chapter 13

## Exponential Functions

### 13.1 Transforming Exponential Functions

Given  $f(x) = e^x$ , determine the specific transformations done to  $f(x)$  to produce  $g(x)$ .

1.  $g(x) = -3e^{x+1}$

2.  $g(x) = \frac{1}{4}e^{-5x} - 2$

3.  $g(x) = e^{2x+7}$

4.  $g(x) = 5e^{-x-2} + 1$

5.  $g(x) = 0.1e^{0.25x-3} - 4$

### 13.2 End Behavior

Determine the end behavior of each. Write your answers using limit notation.

1.  $f(x) = 3 + e^{2x}$

2.  $h(x) = 5^{-x}$

3.  $h(x) = -\frac{2}{3}e^{x+7} + 1$

4.  $f(x) = -7e^x + 4$

5.  $g(x) = \frac{1}{3}e^{2x+1} - 5$

6.  $h(x) = -\frac{1}{2}e^{-4x} + 1$



## 13.3 Answer Key

### Transforming Exponential Functions

1. Shift left 1 unit, vertical stretch by factor of 3, reflect across  $x$ -axis
2. Horizontal compression by factor of 5, reflect across  $y$ -axis, vertical compression by factor of 4, shift down 2 units
3. Shift left 7 units, horizontal compression by factor of 2
4. Shift right 2 units, reflect across  $y$ -axis, vertical stretch by factor of 5, shift up 1 unit
5. Shift right 3 units, horizontal compression by factor of 4, vertical compression by factor of 10, shift down 4 units

### End Behavior

1.  $\lim_{x \rightarrow -\infty} f(x) = 3$      $\lim_{x \rightarrow \infty} f(x) = \infty$
2.  $\lim_{x \rightarrow -\infty} f(x) = \infty$      $\lim_{x \rightarrow \infty} f(x) = 0$
3.  $\lim_{x \rightarrow -\infty} h(x) = 1$      $\lim_{x \rightarrow \infty} h(x) = -\infty$
4.  $\lim_{x \rightarrow -\infty} f(x) = 4$      $\lim_{x \rightarrow \infty} f(x) = -\infty$
5.  $\lim_{x \rightarrow -\infty} f(x) = -5$      $\lim_{x \rightarrow \infty} f(x) = \infty$
6.  $\lim_{x \rightarrow -\infty} f(x) = -\infty$      $\lim_{x \rightarrow \infty} f(x) = 1$

# Chapter 14

## Logarithmic Functions

Write each of the following in exponential or logarithmic form.

1.  $\ln(a) = 7$

2.  $\log_4(x + 1) = 9$

3.  $\log(5x) = 30$

4.  $\ln(w) = c$

5.  $5^x = 19$

6.  $8^{-3} = \frac{1}{512}$

7.  $e^{14} = x$

8.  $(1.1)^{-t} = 50$

Find the domain of each. Write your answers in interval notation.

9.  $b(x) = \log_7(x^2 - 8x + 6)$

10.  $a(x) = \ln\left(\frac{x^2 + 3x + 2}{5x + 15}\right)$

11.  $f(x) = -7 \ln(x^2 + 9x + 8)$

12.  $g(x) = \log(5x^2 + 13x - 6)$

13.  $h(x) = 3 \log_2(x^3 + 2x^2 - x - 2)$

14.  $c(x) = \ln(4x^2 - 15x - 4)$

State the end behavior of each.

15.  $j(x) = 5 \log_3(2x - 5) - 2$

## 14.1 Answer Key

1.  $e^7 = a$
2.  $4^9 = x + 1$
3.  $10^{30} = 5x$
4.  $e^c = w$
5.  $\log_5(19) = x$
6.  $\log_8\left(\frac{1}{512}\right) = -3$
7.  $\ln(x) = 14$
8.  $\log_{1.1}(50) = -t$
9.  $(-\infty, 0.838) \cup (7.162, \infty)$
10.  $(-3, -2) \cup (-1, \infty)$
11.  $(-\infty, -8) \cup (-1, \infty)$
12.  $(-\infty, -3) \cup \left(\frac{2}{5}, \infty\right)$
13.  $(-2, -1) \cup (1, \infty)$
14.  $\left(-\infty, -\frac{1}{4}\right) \cup (4, \infty)$
15.  $\lim_{x \rightarrow (5/2)^+} j(x) = -\infty \quad \lim_{x \rightarrow \infty} j(x) = \infty$

# Chapter 15

## Properties of Logarithms

Expand or condense each completely. Simplify numerical answers.

1.  $\log_b \left( \frac{x^2}{y^8} \right)$

2.  $\ln(ez)^3$

3.  $\log_5(x) + \log_5(9) - 2\log_5(w)$

4.  $\log_2(2^a b^3)$

5.  $\ln \left( \frac{w^7}{e^6} \right)$

6.  $5\log_4(m) - 3\log_4(n) + 2\log_4(p)$

Write an equivalent expression for each of the following using natural logarithms.

7.  $\log_7(10)$

8.  $\log_9(x)$

9.  $\log_b(c)$

10.  $\log_3(10)$

11.  $\log_{17}(\pi)$

12.  $\log_w(x)$

Suppose that  $\log_a(b) = 5$ ,  $\log_a(c) = 12$ , and  $\log_a(d) = 9$ . Evaluate each of the following.

13.  $\log_a(bc)$

14.  $\log_a(c^3)$

15.  $\log_a \left( \frac{d}{c} \right)$

16.  $\log_a \left( \frac{bd}{c} \right)$

17.  $\log_a(b^7c)$

18.  $\log_a \left( \frac{c^2}{d} \right)$

19.  $\log_a(\sqrt{bc})$

20.  $\log_a((bd)^2)$

21.  $\log_a(\sqrt[3]{d^2})$

22.  $\log_a(\sqrt{b^5})$

23.  $\log_a \left( \frac{b^6c}{d^3} \right)$

24.  $\log_a(b^2c^3d^4)$

## 15.1 Answer Key

1.  $2 \log_b(x) - 8 \log_b(y)$

2.  $3 + 3 \ln(z)$

3.  $\log_5 \left( \frac{9x}{w^2} \right)$

4.  $a + 3 \log_2(b)$

5.  $7 \ln(w) - 6$

6.  $\log_4 \left( \frac{m^5 p^2}{n^3} \right)$

7.  $\frac{\ln(10)}{\ln(7)}$

8.  $\frac{\ln(x)}{\ln(9)}$

9.  $\frac{\ln(c)}{\ln(b)}$

10.  $\frac{\ln(10)}{\ln(3)}$

11.  $\frac{\ln(\pi)}{\ln(17)}$

12.  $\frac{\ln(x)}{\ln(w)}$

13. 17

14. 36

15. -3

16. 2

17. 47

18. 15

19. 17/2

20. 28

21. 6

22. 25/2

23. 15

24. 82

# Chapter 16

## Exponential Equations

Solve each. Round to 3 decimal places when necessary.

1.  $3e^{x-2} = 7$
2.  $5^x + 4 > 1$
3.  $2^{3x+4} = 32^{x-7}$
4.  $5e^{7x} + 10 = 42$
5.  $7^{4x+1} \geq 343$
6.  $1000e^{0.04x} = 2000$
7.  $3(4.1)^{x-2} = 8$
8.  $2^{x+1} = 5^{7x-5}$
9.  $8(17)^{-5x} = 22$
10.  $-3(11)^{x-10} = -58$
11.  $12^{-10x} + 8 = 80$
12.  $-5(10)^{7x} + 9 = -46$
13.  $8(8)^{10x} - 1 = 55.2$
14.  $3(3)^{-5x} - 8 = 74$
15.  $6(16)^{4x-9} = 19$
16.  $-7(11)^{5x-7} = -3$
17.  $3^{9-6x} - 7 = 26$

### 16.1 Applications

1. Plutonium has a half-life of 24,360 years. If 15 grams are initially present, how long until 9.5 grams remain?
2. Cadmium-109 has a half-life of about 1.267 years. If 50 mg are initially present, how many years will it take for 16 mg to remain?
3. The half-life of bismuth-207 is about 32.9 years. If 90 mg are initially present, how many years will it take for 75 mg to remain?

## 16.2 Answer Key

1.  $x \approx 2.847$
2.  $(-\infty, \infty)$
3.  $x = 19.5$
4.  $x \approx 0.265$
5.  $\left[\frac{1}{2}, \infty\right)$
6.  $x \approx 17.329$
7.  $x \approx 2.695$
8.  $x \approx 0.827$
9.  $x \approx -0.071$
10.  $x \approx 11.235$
11.  $x \approx -0.172$
12.  $x \approx 0.149$
13.  $x \approx 0.094$
14.  $x \approx -0.602$
15.  $x \approx 2.354$
16.  $x \approx 1.323$
17.  $x \approx 0.970$

## Applications

1. Approximately 17,952 years
2. Approximately 2.0828 years
3. Approximately 8.6538 years

# Chapter 17

## Logarithmic Equations and Inequalities

Solve each. Round to 3 decimal places when necessary.

1.  $\log_5(x) + x \log_5(x) > 0$
2.  $\ln(8 - x^2) = \ln(2 - x)$
3.  $\log_{25}\left(\frac{3x+1}{2x-2}\right) = \frac{1}{2}$
4.  $\log_3(2x+1) - \log_3(x-5) = \log_3(x+1)$
5.  $\log_4(x+1) + \log_4(x-5) > 2$
6.  $\log(x+1) - \log(x-5) = \log(x-3)$
7.  $x \log_3(x+2) - \log_3(x+2) = 0$
8.  $\log_{1/2}(x+1) > -3$
9.  $\log_{12}(4x+4) = \log_{12}(5x+1)$
10.  $\log_{15}(-4x+2) = \log_{15}(6-2x)$
11.  $\log_{11}(-5-3x^2) = \log_{11}(-2x^2+6x)$
12.  $\log_{16}(x^2+4) = \log_{16}(2x+3)$
13.  $\log_7(8x-1) = \log_7(x^2+14)$
14.  $-7 \log_5(x+5) = -7$
15.  $7 \log_8(-x) = 28$
16.  $-10 \log_3(x-5) = -20$



## 17.1 Answer Key

1.  $(1, \infty)$
2.  $x = -2$
3.  $x \approx 1.571$
4.  $x \approx 6.873$
5.  $(2, \infty)$
6.  $x = 7$
7.  $x = \pm 1$
8.  $(-1, 7)$
9.  $x = 3$
10.  $x = -2$
11. No Solution
12.  $x = 1$
13.  $x = 3, 5$
14.  $x = 0$
15.  $x = -4096$
16.  $x = 14$

# Chapter 18

## Sequences

Write the first 4 terms of each sequence.

1.  $a_n = 2(-3)^n$

2.  $b_n = \frac{n!}{2^n}$

3.  $c_{n+1} = 5c_n + 1$ ;  $c_1 = 2$

4.  $d_n = \frac{1}{2}d_{n-1} + n$ ;  $d_1 = 3$

Find the indicated term of each sequence. For term values above 10 billion or below 0.00001, write the first 4 digits after the decimal point when the answer is given in scientific notation. **Do not round.**

5.  $a_n = \{343, 667, 991, 1315, \dots\}$ ; Find the 582nd term.

6.  $b_n = \{300, 240, 192, 153.6, \dots\}$ ; Find the 711th term.

7.  $c_n = \left\{1, \frac{1}{3}, \frac{1}{5}, \frac{1}{7}, \dots\right\}$ ; Find the 8,675,309th term.

Given each sequence, find the first 4 digits **after the decimal point** in the **scientific notation** version of each term.

8.  $a_n = 17, 33, 49, 65, \dots$ ;  $a_{21,972}$

9.  $b_n = 25, 36, 49, 64, 81, \dots$   $b_{413,401}$

10.  $c_n = \frac{1}{3}, \frac{1}{6}, \frac{1}{12}, \frac{1}{24}, \dots$   $c_{152}$

## 18.1 Answer Key

1.  $-6, 18, -54, 162$
2.  $\frac{1}{2}, \frac{1}{2}, \frac{3}{4}, \frac{3}{2}$
3.  $2, 11, 56, 281$
4.  $3, \frac{7}{2}, \frac{19}{4}, \frac{51}{8}$
5.  $188,587$
6.  $6882$
7.  $7634$
8.  $5155 (3.51553 \times 10^5)$
9.  $7090 (1.7090369403 \times 10^{11})$
10.  $1677 (1.1677487203 \times 10^{-46})$

# Chapter 19

## Series

Find the sum of each, if possible.

1.  $\sum_{i=1}^{\infty} \left(\frac{1}{5}\right)^i$

2.  $\sum_{i=0}^{\infty} 3 \left(-\frac{2}{3}\right)^i$

3.  $\sum_{k=1}^{\infty} -2 \left(\frac{1}{3}\right)^k$

4.  $\sum_{j=0}^{\infty} -\frac{1}{2} \left(\frac{3}{2}\right)^j$

5.  $\sum_{i=0}^{\infty} 1.2(0.8)^i$

6.  $\sum_{i=1}^{\infty} 1.2(0.8)^i$

7.  $\sum_{i=0}^{\infty} 0.8(1.2)^i$

8.  $\sum_{k=1}^{\infty} \frac{2}{3^k}$

Find the sum of each of the following. Round to 4 decimal places when necessary.

9.  $9 + 13 + 17 + 21 + \cdots + 1565$

10.  $-3 + 6 - 12 + 24 - 48 + \cdots + 50,331,648$

11.  $1 + \frac{1}{2} + \frac{1}{3} + \frac{1}{4} + \frac{1}{5} + \cdots + \frac{1}{981}$

12.  $2 + 4 + 6 + 8 + 10 + \cdots + 38,214$

13.  $3 + 7 + 11 + 15 + \cdots + 11,491$

14.  $\frac{4}{5} + \frac{5}{6} + \frac{6}{7} + \cdots + \frac{742}{743}$

## 19.1 Answer Key

1.  $\frac{1}{4}$
2.  $\frac{9}{5}$
3.  $-1$
4. Diverges
5. 6
6. 4.8
7. Diverges
8. 2
9. 306,930
10.  $-33,554,433$
11. 7.4663
12. 365,096,556
13. 16,511,131
14. 733.8947

# Chapter 20

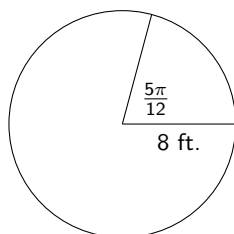
## Angles and Radian Measure

Sketch each of the following. Then find a coterminal between  $0$  and  $360^\circ$  (or  $0$  and  $2\pi$  radians) for each.

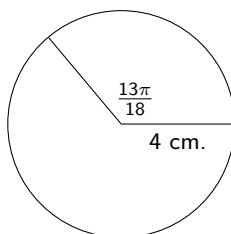
1.  $-\frac{3\pi}{4}$
2.  $900^\circ$
3.  $\frac{27\pi}{10}$
4.  $-125^\circ$

Find the arc length and sector area formed by the central angle of each. Exact answers only.

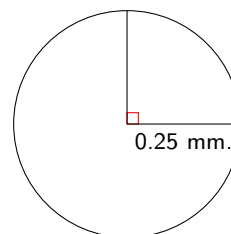
5.



6.



7.

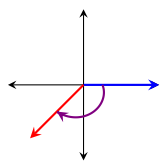


A belt runs on a pulley with radius 4 inches at 250 revolutions per minute.

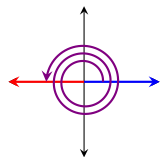
8. Find the angular velocity in rad/sec. Round your answer to 2 decimal places.
9. Find the linear velocity in ft/sec. Round your answer to 2 decimal places.

## 20.1 Answer Key

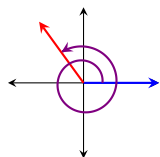
1.  $\frac{5\pi}{4}$



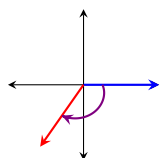
2.  $180^\circ$



3.  $\frac{7\pi}{10}$



4.  $235^\circ$



5.  $s = \frac{10\pi}{3}$  ft.;  $A = \frac{40\pi}{3}$  sq.ft.

6.  $s = \frac{26\pi}{9}$  cm.;  $A = \frac{52\pi}{9}$  sq.cm.

7.  $s = \frac{\pi}{8}$  mm.;  $A = \frac{\pi}{64}$  sq.mm.

8. 26.18 rad/sec

9. 8.73 ft/sec

# Chapter 21

## Trig Functions of Any Angle

Find the exact value of each of the six trig functions of  $\theta$  if  $P$  is a point on the terminal side of  $\theta$ .

1.  $P(-2, 3)$

2.  $P(0, -4)$

3.  $P(-2\sqrt{3}, 2)$

4.  $P(-3, 5)$

5.  $P(-2, 1)$

6.  $P(-4, -7)$

Find the exact values of the 6 trig functions of the following angles.

7.  $\theta = \frac{-17\pi}{4}$

8.  $\theta = \frac{21\pi}{2}$

9.  $\theta = 24\pi$

10.  $-\frac{5\pi}{3}$

11.  $\frac{23\pi}{6}$

12.  $-\frac{\pi}{2}$

13.  $\frac{10\pi}{3}$

14.  $-\frac{\pi}{3}$

15.  $\frac{11\pi}{4}$

16.  $-\frac{13\pi}{2}$



## 21.1 Answer Key

1.  $\sin \theta = \frac{3\sqrt{13}}{13}$ ,  $\cos \theta = \frac{-2\sqrt{13}}{13}$ ,  $\tan \theta = -\frac{3}{2}$ ,  $\csc \theta = \frac{\sqrt{13}}{3}$ ,  $\sec \theta = -\frac{\sqrt{13}}{2}$ ,  $\cot \theta = -\frac{2}{3}$
2.  $\sin \theta = -1$ ,  $\cos \theta = 0$ ,  $\tan \theta = \text{undef.}$ ,  $\csc \theta = -1$ ,  $\sec \theta = \text{undef.}$ ,  $\cot \theta = 0$
3.  $\sin \theta = \frac{1}{2}$ ,  $\cos \theta = -\frac{\sqrt{3}}{2}$ ,  $\tan \theta = -\frac{\sqrt{3}}{3}$ ,  $\csc \theta = 2$ ,  $\sec \theta = -\frac{2\sqrt{3}}{3}$ ,  $\cot \theta = -\sqrt{3}$
4.  $\sin \theta = \frac{5\sqrt{34}}{34}$ ,  $\cos \theta = -\frac{3\sqrt{34}}{34}$ ,  $\tan \theta = -\frac{5}{3}$ ,  $\csc \theta = \frac{\sqrt{34}}{5}$ ,  $\sec \theta = -\frac{\sqrt{34}}{3}$ ,  $\cot \theta = -\frac{3}{5}$
5.  $\sin \theta = \frac{\sqrt{5}}{5}$ ,  $\cos \theta = -\frac{2\sqrt{5}}{5}$ ,  $\tan \theta = -\frac{1}{2}$ ,  $\csc \theta = \sqrt{5}$ ,  $\sec \theta = -\frac{\sqrt{5}}{2}$ ,  $\cot \theta = -2$
6.  $\sin \theta = -\frac{7\sqrt{65}}{65}$ ,  $\cos \theta = -\frac{4\sqrt{65}}{65}$ ,  $\tan \theta = \frac{7}{4}$ ,  $\csc \theta = -\frac{\sqrt{65}}{7}$ ,  $\sec \theta = -\frac{\sqrt{65}}{4}$ ,  $\cot \theta = \frac{4}{7}$
7.  $\sin \theta = -\frac{\sqrt{2}}{2}$ ,  $\cos \theta = \frac{\sqrt{2}}{2}$ ,  $\tan \theta = -1$ ,  $\csc \theta = -\sqrt{2}$ ,  $\sec \theta = \sqrt{2}$ ,  $\cot \theta = -1$
8.  $\sin \theta = 1$ ,  $\cos \theta = 0$ ,  $\tan \theta = \text{undefined}$ ,  $\csc \theta = 1$ ,  $\sec \theta = \text{undefined}$ ,  $\cot \theta = 0$
9.  $\sin \theta = 0$ ,  $\cos \theta = 1$ ,  $\tan \theta = 0$ ,  $\csc \theta = \text{undefined}$ ,  $\sec \theta = 1$ ,  $\cot \theta = \text{undefined}$
10.  $\sin \left(-\frac{5\pi}{3}\right) = \frac{\sqrt{3}}{2}$ ,  $\cos \left(-\frac{5\pi}{3}\right) = \frac{1}{2}$ ,  $\tan \left(-\frac{5\pi}{3}\right) = \sqrt{3}$ ,  $\csc \left(-\frac{5\pi}{3}\right) = \frac{2\sqrt{3}}{3}$ ,  $\sec \left(-\frac{5\pi}{3}\right) = 2$ ,  $\cot \left(-\frac{5\pi}{3}\right) = \frac{\sqrt{3}}{3}$
11.  $\sin \left(\frac{23\pi}{6}\right) = -\frac{1}{2}$ ,  $\cos \left(\frac{23\pi}{6}\right) = \frac{\sqrt{3}}{2}$ ,  $\tan \left(\frac{23\pi}{6}\right) = -\frac{\sqrt{3}}{3}$ ,  $\csc \left(\frac{23\pi}{6}\right) = -2$ ,  $\sec \left(\frac{23\pi}{6}\right) = \frac{2\sqrt{3}}{3}$ ,  $\cot \left(\frac{23\pi}{6}\right) = -\sqrt{3}$
12.  $\sin \left(-\frac{\pi}{2}\right) = -1$ ,  $\cos \left(-\frac{\pi}{2}\right) = 0$ ,  $\tan \left(-\frac{\pi}{2}\right) = \text{undefined}$ ,  $\csc \left(-\frac{\pi}{2}\right) = -1$ ,  $\sec \left(-\frac{\pi}{2}\right) = \text{undefined}$ ,  $\cot \left(-\frac{\pi}{2}\right) = 0$
13.  $\sin \left(\frac{10\pi}{3}\right) = -\frac{\sqrt{3}}{2}$ ,  $\cos \left(\frac{10\pi}{3}\right) = -\frac{1}{2}$ ,  $\tan \left(\frac{10\pi}{3}\right) = \sqrt{3}$ ,  $\csc \left(\frac{10\pi}{3}\right) = -\frac{2\sqrt{3}}{3}$ ,  $\sec \left(\frac{10\pi}{3}\right) = -2$ ,  $\cot \left(\frac{10\pi}{3}\right) = \frac{\sqrt{3}}{3}$
14.  $\sin \left(-\frac{\pi}{3}\right) = -\frac{\sqrt{3}}{2}$ ,  $\cos \left(-\frac{\pi}{3}\right) = \frac{1}{2}$ ,  $\tan \left(-\frac{\pi}{3}\right) = -\sqrt{3}$ ,  $\csc \left(-\frac{\pi}{3}\right) = -\frac{2\sqrt{3}}{3}$ ,  $\sec \left(-\frac{\pi}{3}\right) = 2$ ,  $\cot \left(-\frac{\pi}{3}\right) = -\frac{\sqrt{3}}{3}$
15.  $\sin \left(\frac{11\pi}{4}\right) = \frac{\sqrt{2}}{2}$ ,  $\cos \left(\frac{11\pi}{4}\right) = -\frac{\sqrt{2}}{2}$ ,  $\tan \left(\frac{11\pi}{4}\right) = -1$ ,  $\csc \left(\frac{11\pi}{4}\right) = \sqrt{2}$ ,  $\sec \left(\frac{11\pi}{4}\right) = -\sqrt{2}$ ,  $\cot \left(\frac{11\pi}{4}\right) = -1$
16.  $\sin \left(-\frac{13\pi}{2}\right) = -1$ ,  $\cos \left(-\frac{13\pi}{2}\right) = 0$ ,  $\tan \left(-\frac{13\pi}{2}\right) = \text{undefined}$ ,  $\csc \left(-\frac{13\pi}{2}\right) = -1$ ,  $\sec \left(-\frac{13\pi}{2}\right) = \text{undefined}$ ,  
 $\cot \left(-\frac{13\pi}{2}\right) = 0$

# Chapter 22

## Graphs of Sine and Cosine Functions

Determine the amplitude, period, phase shift, and vertical shift for each. Exact answers only.

1.  $f(x) = -2 \sin\left(3x - \frac{\pi}{4}\right) + 1$

2.  $g(x) = \frac{1}{3} \cos\left(\frac{1}{2}x + 2\right)$

3.  $f(x) = 2 \sin\left(x - \frac{\pi}{3}\right) + 7$

4.  $f(x) = -4 \cos\left(\frac{2}{3}x - \frac{2\pi}{3}\right)$

5.  $h(x) = \sin\left(\frac{3}{4}x + \frac{\pi}{12}\right) - 8$

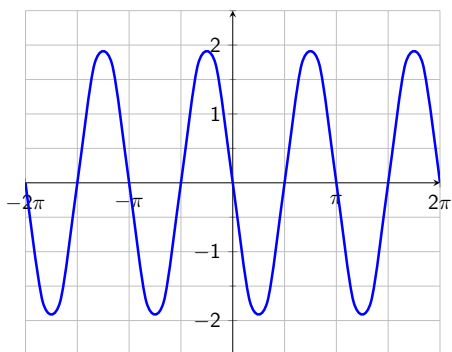
6.  $f(x) = 3 \sin\left(2x + \frac{\pi}{2}\right) - \sqrt{3}$

7.  $f(x) = -4 \cos\left(4x - \frac{\pi}{3}\right) + \pi$

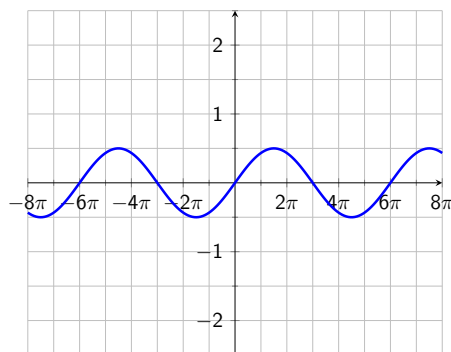
8.  $g(x) = \frac{4}{9} \cos\left(\frac{3}{10}x + \frac{3\pi}{2}\right) - 1$

Write the equation of each of the following in the form  $y = a \sin(bx)$ .

9.



10.



## 22.1 Answer Key

1. Amp = 2, Per =  $\frac{2\pi}{3}$ , P.S. =  $\frac{\pi}{12} \rightarrow$ , V.S. = 1  $\uparrow$
2. Amp =  $\frac{1}{3}$ , Per =  $4\pi$ , P.S. =  $4 \leftarrow$ , V.S. = None
3. Amp = 2, Period =  $2\pi$ , P.S. =  $\frac{\pi}{3}$  right, V.S. = 7 up
4. Amp = 4, Period =  $3\pi$ , P.S. =  $\pi$  right, V.S. = 0 (or none)
5. Amp = 1, Per =  $\frac{8\pi}{3}$ , P.S. =  $\frac{\pi}{9}$  left, V.S. = 8 down
6. Amp = 3, Period =  $\pi$ , P.S. =  $\frac{\pi}{4}$  left, V.S. =  $\sqrt{3}$  down
7. Amp = 4, Period =  $\frac{\pi}{2}$ , P.S. =  $\frac{\pi}{12}$  right, V.S. =  $\pi$  up
8. Amp =  $\frac{4}{9}$ , Period =  $\frac{20\pi}{3}$ , P.S. =  $5\pi$  left, V.S. = 1 down
9.  $y = -2\sin(2x)$
10.  $y = \frac{1}{2}\sin\left(\frac{1}{3}x\right)$

# Chapter 23

## Graphs of Other Trig Functions

Determine the amplitude, period, phase shift, and vertical shift for each. Exact answers only.

1.  $h(x) = \tan\left(\frac{3}{4}x + \frac{\pi}{12}\right) - 8$

2.  $f(x) = 3 \tan\left(2x + \frac{\pi}{2}\right) - \sqrt{3}$

3.  $f(x) = -4 \cot\left(4x - \frac{\pi}{3}\right) + \pi$

4.  $g(x) = \frac{4}{9} \cot\left(\frac{3}{10}x + \frac{3\pi}{2}\right) - 1$

5.  $h(x) = \sec\left(\frac{3}{4}x + \frac{\pi}{12}\right) - 8$

6.  $f(x) = 3 \sec\left(2x + \frac{\pi}{2}\right) - \sqrt{3}$

7.  $f(x) = -4 \csc\left(4x - \frac{\pi}{3}\right) + \pi$

8.  $g(x) = \frac{4}{9} \csc\left(\frac{3}{10}x + \frac{3\pi}{2}\right) - 1$

9.  $f(x) = \frac{1}{10} \cot\left(3x + \frac{3\pi}{4}\right) + 5$

10.  $g(x) = 6 \csc\left(2x - \frac{\pi}{6}\right) + 5$

11.  $h(x) = 4 \csc\left(8x - \frac{\pi}{6}\right) - 1$

12.  $k(x) = \tan\left(\frac{1}{7}x + \frac{\pi}{4}\right) - 5$

13.  $f(x) = 7 \tan\left(8x + \frac{\pi}{6}\right)$

14.  $g(x) = 6 \tan\left(7x - \frac{\pi}{4}\right) - 4$

15.  $h(x) = 4 \tan(5x) - 5$

16.  $k(x) = \cot\left(\frac{1}{3}x - \frac{2\pi}{3}\right) - 5$

17.  $f(x) = 10 \cot\left(\frac{1}{8}x - \frac{\pi}{2}\right)$

18.  $g(x) = 10 \cot\left(5x - \frac{\pi}{4}\right) + 5$

## 23.1 Answer Key

1. Amp =  $n/a$ , Per =  $\frac{4\pi}{3}$ , P.S. =  $\frac{\pi}{9}$  left, V.S. = 8 down
2. Amp =  $n/a$ , Period =  $\frac{\pi}{2}$ , P.S. =  $\frac{\pi}{4}$  left, V.S. =  $\sqrt{3}$  down
3. Amp =  $n/a$ , Period =  $\frac{\pi}{4}$ , P.S. =  $\frac{\pi}{12}$  right, V.S. =  $\pi$  up
4. Amp =  $n/a$ , Period =  $\frac{10\pi}{3}$ , P.S. =  $5\pi$  left, V.S. = 1 down
5. Amp =  $n/a$ , Per =  $\frac{8\pi}{3}$ , P.S. =  $\frac{\pi}{9}$  left, V.S. = 8 down
6. Amp =  $n/a$ , Period =  $\pi$ , P.S. =  $\frac{\pi}{4}$  left, V.S. =  $\sqrt{3}$  down
7. Amp =  $n/a$ , Period =  $\frac{\pi}{2}$ , P.S. =  $\frac{\pi}{12}$  right, V.S. =  $\pi$  up
8. Amp =  $n/a$ , Period =  $\frac{20\pi}{3}$ , P.S. =  $5\pi$  left, V.S. = 1 down
9. Amp =  $n/a$ , Period =  $\frac{\pi}{3}$ , P.S. =  $\frac{\pi}{4}$  left, V.S. = 5 up
10. Amp =  $n/a$ , Period =  $\pi$ , P.S. =  $\frac{\pi}{12}$  right, V.S. = 5 up
11. Amp =  $n/a$ , Period =  $\frac{\pi}{4}$ , P.S. =  $\frac{\pi}{48}$  right, V.S. = 1 down
12. Amp =  $n/a$ , Period =  $7\pi$ , P.S. =  $\frac{7\pi}{4}$  left, V.S. = 5 down
13. Amp =  $n/a$ , Period =  $\frac{\pi}{8}$ , P.S. =  $\frac{\pi}{48}$  left, V.S. = 0 (or none)
14. Amp =  $n/a$ , Period =  $\frac{\pi}{7}$ , P.S. =  $\frac{\pi}{28}$  right, V.S. = 4 down
15. Amp =  $n/a$ , Period =  $\frac{\pi}{5}$ , P.S. = 0 (or none), V.S. = 5 down
16. Amp =  $n/a$ , Period =  $3\pi$ , P.S. =  $2\pi$  right, V.S. = 5 down
17. Amp =  $n/a$ , Period =  $8\pi$ , P.S. =  $4\pi$  right, V.S. = 0 (or none)
18. Amp =  $n/a$ , Period =  $\frac{\pi}{5}$ , P.S. =  $\frac{\pi}{20}$  right, V.S. = 5 up

# Chapter 24

## Inverse Trig Functions

State the exact, simplified value of each or write as an expression of  $x$ .

1.  $\cot^{-1}(-1)$

2.  $\sin^{-1}\left(-\frac{\sqrt{3}}{2}\right)$

3.  $\tan^{-1}(0)$

4.  $\sec^{-1}\left(\frac{2\sqrt{3}}{3}\right)$

5.  $\cos^{-1}\left(\frac{1}{2}\right)$

6.  $\sec^{-1}(-2)$

7.  $\tan^{-1}(-\sqrt{3})$

8.  $\sec\left(\sin^{-1}\left(\frac{2}{5}\right)\right)$

9.  $\cot(\sec^{-1}(x))$

10.  $\sin\left(\cos^{-1}\left(\frac{3x}{4}\right)\right)$

11.  $\cot\left(\csc^{-1}\left(-\frac{7}{2}\right)\right)$

12.  $\sec\left(\arcsin\left(\frac{9}{13}\right)\right)$

13.  $\cos(\tan^{-1}(7x))$

14.  $\sin\left(\sec^{-1}\left(\frac{8}{x}\right)\right)$

15.  $\csc\left(\arctan\left(-\frac{3}{2}\right)\right)$

16.  $\cos\left(\sin^{-1}\left(\frac{7}{8}\right)\right)$

17.  $\tan\left(\cos^{-1}\left(\frac{3}{x}\right)\right)$

18.  $\csc\left(\sec^{-1}(\sqrt{2})\right)$

19.  $\tan\left(\sec^{-1}\left(\frac{\sqrt{17}}{4}\right)\right)$

20.  $\sin\left(\tan^{-1}\left(\frac{4x}{5}\right)\right)$

## 24.1 Answer Key

1.  $\frac{3\pi}{4}$

2.  $-\frac{\pi}{3}$

3. 0

4.  $\frac{\pi}{6}$

5.  $\frac{\pi}{3}$

6.  $\frac{2\pi}{3}$

7.  $-\frac{\pi}{3}$

8.  $\frac{5\sqrt{21}}{21}$

9.  $\frac{1}{\sqrt{x^2-1}} = \frac{\sqrt{x^2-1}}{x^2-1}$

10.  $\frac{\sqrt{16-9x^2}}{4}$

11.  $-\frac{3\sqrt{5}}{2}$

12.  $\frac{13\sqrt{22}}{44}$

13.  $\frac{\sqrt{49x^2+1}}{49x^2+1}$

14.  $\frac{\sqrt{64-x^2}}{x}$

15.  $-\frac{\sqrt{13}}{3}$

16.  $\frac{\sqrt{15}}{8}$

17.  $\frac{\sqrt{x^2-9}}{3}$

18.  $\sqrt{2}$

19.  $\sqrt{17}$

20.  $\frac{4x}{\sqrt{16x^2+25}}$

# Chapter 25

## Trig Equations and Inequalities

Solve each in the interval  $[0, 2\pi)$ . Write your answers to inequalities using interval notation.

1.  $\tan(6x) = 1$

2.  $\cot(2x) = -\frac{\sqrt{3}}{3}$

3.  $\sin^2(x) = \frac{3}{4}$

4.  $\sin(2x) = \cos(x)$

5.  $\sin(2x) \geq \sin(x)$

6.  $\cos(2x) < 0$

7.  $2 \sin\left(x - \frac{\pi}{3}\right) = -1$

8.  $3 \tan\left(-2x + \frac{\pi}{2}\right) = \sqrt{3}$

9.  $\sin^2(x) < \frac{1}{2}$

10.  $\tan^2(x) = 3 \sec(x) - 3$

11.  $2 \csc(x) - 3 \csc^2(x) = -2 \csc^2(x) + 1$

12.  $-2 \cot(x) - \csc^2(x) = 0$

13.  $\tan(x) = -\tan(x) \cos(x)$

14.  $3 \cos(x) = 2 \cos^2(x) + 1$

15.  $\csc(x) - \cot^2(x) + 1 = 0$

16.  $-\sin(x) + \sin(2x) = 2 \sin(2x)$

17.  $3 \cos(x) = \sin(2x) + 2 \cos(x)$



## 25.1 Answer Key

1.  $\frac{\pi}{24}, \frac{5\pi}{24}, \frac{3\pi}{8}, \frac{13\pi}{24}, \frac{17\pi}{24}, \frac{7\pi}{8}, \frac{25\pi}{24}, \frac{29\pi}{24}, \frac{11\pi}{8}, \frac{37\pi}{24}, \frac{41\pi}{24}, \frac{15\pi}{8}$
2.  $\frac{\pi}{3}, \frac{5\pi}{6}, \frac{4\pi}{3}, \frac{11\pi}{6}$
3.  $\frac{\pi}{3}, \frac{2\pi}{3}, \frac{4\pi}{3}, \frac{5\pi}{3}$
4.  $\frac{\pi}{2}, \frac{5\pi}{6}, \frac{3\pi}{2}$
5.  $\left[0, \frac{\pi}{3}\right] \cup \left[\pi, \frac{5\pi}{3}\right]$
6.  $\left(\frac{\pi}{4}, \frac{3\pi}{4}\right) \cup \left(\frac{5\pi}{4}, \frac{7\pi}{4}\right)$
7.  $x = \frac{\pi}{6}, \frac{3\pi}{2}$
8.  $x = \frac{\pi}{6}, \frac{2\pi}{3}, \frac{7\pi}{6}, \frac{5\pi}{3}$
9.  $\left[0, \frac{\pi}{4}\right) \cup \left(\frac{3\pi}{4}, \frac{5\pi}{4}\right) \cup \left(\frac{7\pi}{4}, 2\pi\right)$
10.  $x = 0, \frac{\pi}{3}, \frac{5\pi}{3}$
11.  $x = \frac{\pi}{2}$
12.  $x = \frac{3\pi}{4}, \frac{7\pi}{4}$
13.  $x = 0, \pi$
14.  $x = 0, \frac{\pi}{3}, \frac{5\pi}{3}$
15.  $x = \frac{\pi}{6}, \frac{5\pi}{6}, \frac{3\pi}{2}$
16.  $x = 0, \frac{2\pi}{3}, \pi, \frac{4\pi}{3}$
17.  $x = \frac{\pi}{6}, \frac{\pi}{2}, \frac{5\pi}{6}, \frac{3\pi}{2}$

# Chapter 26

## Law of Sines and Cosines

Solve each of the following. Round your answers to 1 decimal place.

1.  $m\angle B = 37.8^\circ$ ,  $a = 15$ ,  $c = 21.1$
2.  $m\angle A = 41.9^\circ$ ,  $m\angle C = 59.2^\circ$ ,  $a = 10.2$
3.  $a = 14$ ,  $b = 19.6$ ,  $c = 13.1$
4.  $c = 29$ ,  $b = 23$ ,  $m\angle A = 55^\circ$
5.  $c = 8$ ,  $b = 12$ ,  $m\angle A = 90^\circ$
6.  $m\angle B = 67.2^\circ$ ,  $a = 15.6$ ,  $c = 18.9$
7.  $b = 20$ ,  $a = 30$ ,  $c = 12$
8.  $a = 14$ ,  $b = 6$ ,  $c = 12$
9.  $a = 7$ ,  $b = 14$ ,  $c = 12$
10.  $m\angle B = 119^\circ$ ,  $a = 11$ ,  $b = 28$
11.  $m\angle A = 125^\circ$ ,  $c = 21$ ,  $a = 28$
12.  $m\angle B = 108^\circ$ ,  $m\angle C = 61^\circ$ ,  $b = 25$

## 26.1 Answer Key

1.  $b \approx 13.0$ ,  $m\angle A \approx 44.8^\circ$ ,  $m\angle C \approx 97.4^\circ$
2.  $m\angle B = 78.9^\circ$ ,  $b \approx 15.0$ ,  $c \approx 13.1$
3.  $m\angle A \approx 45.5^\circ$ ,  $m\angle B \approx 92.6^\circ$ ,  $m\angle C \approx 41.9^\circ$
4.  $m\angle B \approx 50.1^\circ$ ,  $m\angle C \approx 74.9^\circ$ ,  $a \approx 24.6$
5.  $m\angle B \approx 56.3^\circ$ ,  $m\angle C \approx 33.7^\circ$ ,  $a \approx 14.4$
6.  $m\angle A \approx 48.2^\circ$ ,  $m\angle C \approx 64.6^\circ$ ,  $b \approx 19.3$
7.  $m\angle A \approx 137.8^\circ$ ,  $m\angle B \approx 26.6^\circ$ ,  $m\angle C \approx 15.6^\circ$
8.  $m\angle A \approx 96.4^\circ$ ,  $m\angle B \approx 25.2^\circ$ ,  $m\angle C \approx 58.4^\circ$
9.  $m\angle A \approx 30^\circ$ ,  $m\angle B \approx 91^\circ$ ,  $m\angle C \approx 59^\circ$
10.  $m\angle A \approx 20.1^\circ$ ,  $m\angle C \approx 40.9^\circ$ ,  $c \approx 21$
11.  $m\angle B \approx 17.1^\circ$ ,  $m\angle C \approx 37.9^\circ$ ,  $b \approx 10.1$
12.  $m\angle A \approx 11^\circ$ ,  $a \approx 5$ ,  $c \approx 23$

# Chapter 27

## Area of Triangles

Find the area of each. Round your answers to 1 decimal place.

1.  $m\angle B = 37.8^\circ$ ,  $a = 15$ ,  $c = 21.1$
2.  $m\angle A = 41.9^\circ$ ,  $m\angle C = 59.2^\circ$ ,  $a = 10.2$
3.  $a = 14$ ,  $b = 19.6$ ,  $c = 13.1$
4.  $p = 14$ ,  $k = 9$ ,  $h = 9$
5.  $m\angle T = 15^\circ$ ,  $m\angle S = 140^\circ$ ,  $r = 11.1$
6.  $m\angle Z = 67^\circ$ ,  $y = 6$ ,  $m\angle Y = 41^\circ$
7.  $m\angle R = 129^\circ$ ,  $r = 10$ ,  $m\angle P = 28^\circ$
8.  $a = 6.9$ ,  $m\angle B = 115^\circ$ ,  $m\angle C = 39^\circ$
9.  $d = 6$ ,  $3 = 12$ ,  $f = 8$
10.  $m\angle Y = 120^\circ$ ,  $x = 13$ ,  $m\angle Z = 21^\circ$
11.  $z = 10$ ,  $y = 14$ ,  $x = 6$
12.  $m\angle P = 18^\circ$ ,  $h = 6.9$ ,  $m\angle H = 147^\circ$
13.  $m\angle S = 118^\circ$ ,  $m\angle T = 30^\circ$ ,  $s = 6.3$
14.  $r = 8$ ,  $t = 7.5$ ,  $m\angle S = 50^\circ$
15.  $d = 15.3$ ,  $m\angle E = 105^\circ$ ,  $f = 5$
16.  $m\angle R = 31^\circ$ ,  $p = 12$ ,  $m\angle Q = 26^\circ$
17.  $m\angle D = 120^\circ$ ,  $f = 4$ ,  $m\angle E = 36^\circ$

## 27.1 Answer Key

1. Approximately 97.0 sq. units
2. Approximately 65.7 sq. units
3. Approximately 91.6 sq. units
4. Approximately 39.6 sq. units
5. Approximately 24.3 sq. units
6. Approximately 24.0 sq. units
7. Approximately 11.7 sq. units
8. Approximately 31.0 sq. units
9. Approximately 21.3 sq. units
10. Approximately 41.7 sq. units
11. Approximately 26.0 sq. units
12. Approximately 3.5 sq. units
13. Approximately 6.0 sq. units
14. Approximately 23.0 sq. units
15. Approximately 36.9 sq. units
16. Approximately 19.5 sq. units
17. Approximately 10.0 sq. units

# Chapter 28

## Polar Coordinates

Convert each to exact rectangular coordinates.

1.  $\left(3, \frac{5\pi}{6}\right)$
2.  $\left(-2, -\frac{\pi}{4}\right)$
3.  $\left(\frac{5}{2}, 240^\circ\right)$
4.  $(3, 300^\circ)$
5.  $(-3, -90^\circ)$
6.  $\left(1, \frac{3\pi}{2}\right)$
7.  $\left(-1, \frac{7\pi}{4}\right)$
8.  $\left(-2, \frac{5\pi}{3}\right)$
9.  $\left(1, -\frac{4\pi}{3}\right)$
10.  $(-4, 150^\circ)$
11.  $\left(2, -\frac{7\pi}{4}\right)$
12.  $(-2, 180^\circ)$
13.  $\left(-1, \frac{\pi}{4}\right)$

Convert each to exact polar coordinates. Use  $r > 0$  and  $0 \leq \theta < 2\pi$ .

14.  $(-2\sqrt{3}, -2)$
15.  $\left(-\frac{1}{2}, \frac{1}{2}\right)$
16.  $(7\sqrt{2}, -7\sqrt{2})$
17.  $(-2, 0)$
18.  $\left(\frac{\sqrt{3}}{2}, -\frac{1}{2}\right)$
19.  $(2, -2\sqrt{3})$
20.  $\left(\frac{\sqrt{3}}{2}, \frac{1}{2}\right)$
21.  $(2\sqrt{3}, -2)$
22.  $\left(-\frac{1}{2}, \frac{\sqrt{3}}{2}\right)$
23.  $(0, 4)$
24.  $(3, 0)$
25.  $(1, 0)$
26.  $\left(-\frac{\sqrt{2}}{2}, -\frac{\sqrt{2}}{2}\right)$

Convert each to either rectangular or polar coordinates.

27.  $2x + 5y = 9$
28.  $3y = 1$
29.  $-5x - 8y = -10$
30.  $r = 8$
31.  $r = 4 \sec(\theta)$
32.  $\theta = -\frac{\pi}{6}$

## 28.1 Answer Key

1.  $\left(-\frac{3\sqrt{3}}{2}, \frac{3}{2}\right)$
2.  $(-\sqrt{2}, \sqrt{2})$
3.  $\left(\frac{5}{4}, \frac{5\sqrt{3}}{4}\right)$
4.  $\left(\frac{3}{2}, -\frac{3\sqrt{3}}{2}\right)$
5.  $(0, 3)$
6.  $(0, -1)$
7.  $\left(-\frac{\sqrt{2}}{2}, \frac{\sqrt{2}}{2}\right)$
8.  $(-1, \sqrt{3})$
9.  $\left(-\frac{1}{2}, \frac{\sqrt{3}}{2}\right)$
10.  $(2\sqrt{3}, -2)$
11.  $(\sqrt{2}, \sqrt{2})$
12.  $(2, 0)$
13.  $\left(-\frac{\sqrt{2}}{2}, -\frac{\sqrt{2}}{2}\right)$
14.  $\left(4, \frac{7\pi}{6}\right)$
15.  $\left(\frac{\sqrt{2}}{2}, \frac{3\pi}{4}\right)$
16.  $\left(14, \frac{7\pi}{4}\right)$
17.  $(2, \pi)$
18.  $\left(1, \frac{11\pi}{6}\right)$
19.  $\left(4, \frac{5\pi}{3}\right)$
20.  $\left(1, \frac{\pi}{6}\right)$
21.  $\left(4, \frac{11\pi}{6}\right)$
22.  $\left(1, \frac{2\pi}{3}\right)$
23.  $\left(4, \frac{\pi}{2}\right)$
24.  $(3, 0)$
25.  $(1, 0)$
26.  $\left(1, \frac{5\pi}{4}\right)$
27.  $r = \frac{9}{2 \cos \theta + 5 \sin \theta}$
28.  $r = \frac{1}{3} \csc \theta$
29.  $r = \frac{10}{5 \cos \theta + 8 \sin \theta}$
30.  $x^2 + y^2 = 64$
31.  $x = 4$
32.  $y = -\frac{\sqrt{3}}{3}x$

# Chapter 29

## Vectors

Given  $\vec{v} = 3\mathbf{i} - 5\mathbf{j}$  and  $\vec{w} = \langle -2, 1 \rangle$ , find each. Exact and simplified answers only.

1.  $\vec{v} + \vec{w}$

2.  $-4\vec{w}$

3.  $|\vec{v}|$

4.  $\hat{w}$

Given  $\vec{a} = \langle 4, -3 \rangle$ ,  $\mathbf{b} = 11\mathbf{i} + 2\mathbf{j}$ , and  $\vec{c} = \langle 0, 2 \rangle$ , find each. Exact and simplified answers only.

5.  $\vec{a} + \vec{b}$

6.  $\vec{a} - \vec{b}$

7.  $\mathbf{a} + \mathbf{c}$

8.  $-\mathbf{b}$

9.  $2\vec{c}$

10.  $3\vec{a} + 5\vec{b}$

11.  $-2\vec{c} - 1.5\vec{a}$

12.  $||\vec{b}||$

13.  $|\mathbf{c}|$

14.  $\hat{a}$

15.  $\hat{b}$

16.  $\hat{c}$

Find the exact horizontal and vertical component form of each vector with the given magnitude and direction angle.

17.  $|u| = 8, \quad \theta = 120^\circ$

18.  $|u| = 5, \quad \theta = \frac{\pi}{4}$

19.  $|u| = 1.5, \quad \theta = -300^\circ$

20.  $|u| = \sqrt{2}, \quad \theta = \frac{3\pi}{2}$

21.  $|u| = 4, \quad \theta = 210^\circ$

22.  $|u| = 2\sqrt{3}, \quad \theta = -\frac{\pi}{6}$

Write each of the following in  $|\vec{v}|\langle \cos(\theta), \sin(\theta) \rangle$  form, where  $0 \leq \theta < 2\pi$ .

23.  $\vec{v} = \langle \sqrt{2}, -\sqrt{2} \rangle$

24.  $\vec{v} = \langle -1, \sqrt{3} \rangle$

25.  $\vec{v} = \langle 0, 4 \rangle$



## 29.1 Answer Key

1.  $\mathbf{i} - 4\mathbf{j}$

4.  $\left\langle -\frac{2\sqrt{5}}{5}, \frac{\sqrt{5}}{5} \right\rangle$

7.  $\langle 4, -1 \rangle$

10.  $\langle 67, 1 \rangle$

13. 2

16.  $\langle 0, 1 \rangle$

19.  $\left\langle \frac{3}{4}, \frac{3\sqrt{3}}{4} \right\rangle$

22.  $\langle 3, -\sqrt{3} \rangle$

25.  $4 \left\langle \cos\left(\frac{\pi}{2}\right), \sin\left(\frac{\pi}{2}\right) \right\rangle$

2.  $\langle 8, -4 \rangle$

5.  $\langle 15, -1 \rangle$

8.  $\langle -11, -2 \rangle$

11.  $\langle -6, 0.5 \rangle$

14.  $\left\langle \frac{4}{5}, -\frac{3}{5} \right\rangle$

17.  $\langle -4, 4\sqrt{3} \rangle$

20.  $\langle 0, -\sqrt{2} \rangle$

23.  $2 \left\langle \cos\left(\frac{7\pi}{4}\right), \sin\left(\frac{7\pi}{4}\right) \right\rangle$

3.  $\sqrt{34}$

6.  $\langle -7, -5 \rangle$

9.  $\langle 0, 4 \rangle$

12.  $5\sqrt{5}$

15.  $\left\langle \frac{11\sqrt{5}}{25}, \frac{2\sqrt{5}}{25} \right\rangle$

18.  $\left\langle \frac{5\sqrt{2}}{2}, \frac{5\sqrt{2}}{2} \right\rangle$

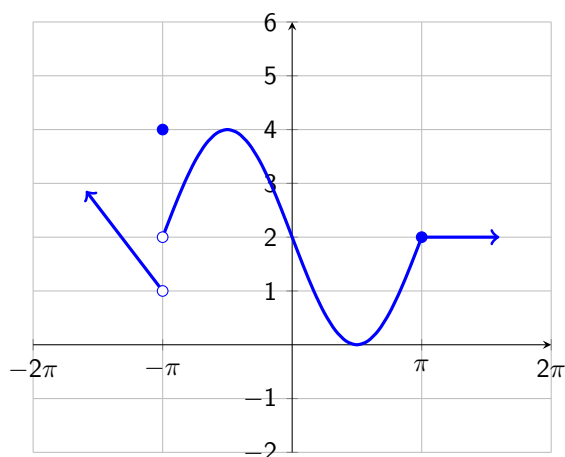
21.  $\langle -2\sqrt{3}, -2 \rangle$

24.  $2 \left\langle \cos\left(\frac{2\pi}{3}\right), \sin\left(\frac{2\pi}{3}\right) \right\rangle$

# Chapter 30

## Numerical and Graphical Limits

Solve using the graph of  $f(x)$  below.



1.  $\lim_{x \rightarrow -\pi^-} f(x)$

2.  $\lim_{x \rightarrow -\pi^+} f(x)$

3.  $\lim_{x \rightarrow -\pi} f(x)$

4.  $f(-\pi)$

5.  $\lim_{x \rightarrow \pi^-} f(x)$

6.  $\lim_{x \rightarrow \pi^+} f(x)$

7.  $\lim_{x \rightarrow \pi} f(x)$

8.  $f(\pi)$

Find each limit.

9.  $\lim_{x \rightarrow 0} \frac{e^x - 1}{x}$

10.  $\lim_{x \rightarrow 1^+} \log(x - 1)$

11.  $\lim_{x \rightarrow 2} \left( \frac{3e^{1/(x-2)}}{e^{1/(x-2)} + 1} - 1 \right)$

12.  $\lim_{x \rightarrow 0} f(x), f(x) = \begin{cases} -x^2 - 4x - 5, & x \leq 0 \\ x - 5, & x > 0 \end{cases}$

13.  $\lim_{x \rightarrow 4} g(x), g(x) = \begin{cases} x + 4, & x < -4 \\ \frac{x}{2} + 3, & x \geq -4 \end{cases}$

14.  $\lim_{x \rightarrow 0} h(x), h(x) = \begin{cases} -x - 4, & x < 0 \\ -2x - 5, & x \geq 0 \end{cases}$

## 30.1 Answer Key

1. 1
2. 2
3. Does not exist
4. 4
5. 2
6. 2
7. 2
8. 2
9.  $e \approx 2.71828$
10. Does not exist
11. Does not exist
12.  $-5$
13. 1
14. Does not exist

# Chapter 31

## Limits and Algebra

Find each limit algebraically.

1.  $\lim_{x \rightarrow -4} \left( \frac{x+4}{x^2+6x+8} \right)$

3.  $\lim_{x \rightarrow 3} \left( \frac{x-3}{x^2-8x+15} \right)$

5.  $\lim_{x \rightarrow -1} \left( -\frac{x^2+5x+4}{x+1} \right)$

7.  $\lim_{x \rightarrow 2} \left( \frac{x^2-2x}{x-2} \right)$

9.  $\lim_{x \rightarrow 0} \left( \frac{x}{\frac{1}{x-1}+1} \right)$

11.  $\lim_{x \rightarrow 3} \left( \frac{x}{\frac{1}{x-3}+\frac{1}{3}} \right)$

13.  $\lim_{x \rightarrow 1} \left( \frac{x}{\frac{1}{x-1}+1} \right)$

15.  $\lim_{x \rightarrow 1} \left( \frac{\sqrt{x}-1}{x-1} \right)$

17.  $\lim_{x \rightarrow 25} \left( \frac{x-25}{\sqrt{x}-5} \right)$

19.  $\lim_{x \rightarrow 9} \left( \frac{x-9}{\sqrt{x}-3} \right)$

2.  $\lim_{x \rightarrow -3} \left( -\frac{x^2+2x-3}{x+3} \right)$

4.  $\lim_{x \rightarrow -2} \left( \frac{x^2-2x-8}{x+2} \right)$

6.  $\lim_{x \rightarrow -4} \left( \frac{x^2+7x+12}{x+4} \right)$

8.  $\lim_{x \rightarrow -1} \left( -\frac{x^2-3x-4}{x+1} \right)$

10.  $\lim_{x \rightarrow 0} \left( \frac{x}{\frac{1}{x+2}-\frac{1}{2}} \right)$

12.  $\lim_{x \rightarrow 2} \left( \frac{x}{\frac{1}{x-2}+\frac{1}{2}} \right)$

14.  $\lim_{x \rightarrow -1} \left( \frac{x}{\frac{1}{x+1}-1} \right)$

16.  $\lim_{x \rightarrow 2} \left( \frac{\sqrt{x+7}-3}{x-2} \right)$

18.  $\lim_{x \rightarrow 1} \left( \frac{x-1}{\sqrt{x+8}-3} \right)$

20.  $\lim_{x \rightarrow 2} \left( \frac{\sqrt{x+14}-4}{x-1} \right)$

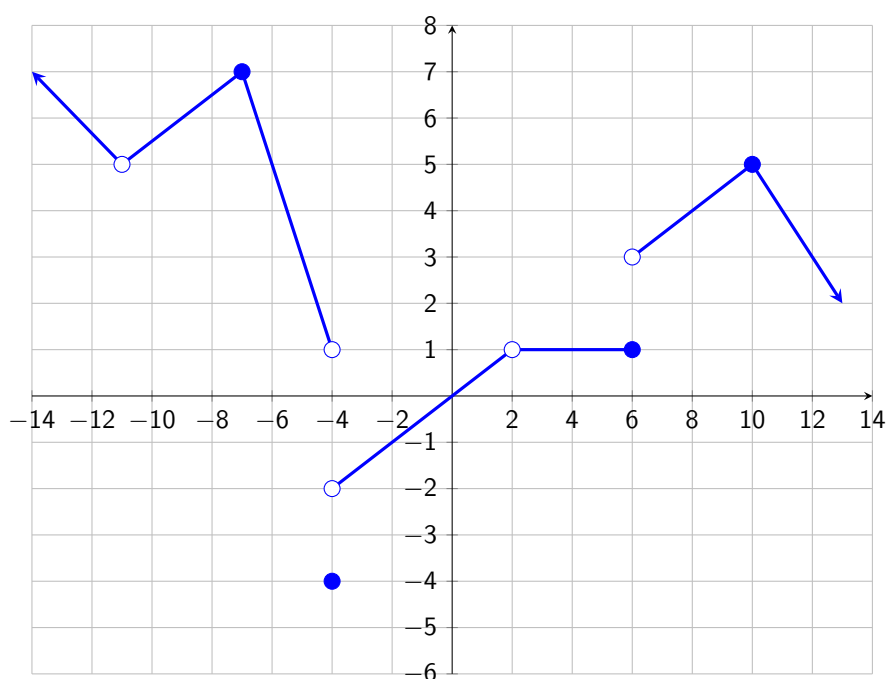
## 31.1 Answer Key

1.  $-\frac{1}{2}$
2. 4
3.  $-\frac{1}{2}$
4. -6
5. -3
6. -1
7. 2
8. 5
9. -1
10. -4
11. 0
12. 0
13. 0
14. 0
15.  $\frac{1}{2}$
16.  $\frac{1}{6}$
17. 10
18. 6
19. 6
20.  $\frac{1}{8}$

# Chapter 32

## Continuity

For each of the following, determine whether the function graphed below is continuous at that value. If not, explain why.



1.  $x = -11$

2.  $x = -7$

3.  $x = -4$

4.  $x = 2$

5.  $x = 6$

6.  $x = 10$

Identify all discontinuities for each of the following.

7.  $f(x) = \frac{x^2 - 6x}{x^2 + 6x}$

8.  $f(x) = \frac{x + 3}{x - 3}$

9.  $f(x) = \frac{x + 4}{3 \ln(x)}$

10.  $f(x) = \frac{2x + 5}{x^2 - 9}$

11.  $f(x) = \begin{cases} 2 \sin(x), & x < 0 \\ 0, & x = 0 \\ 3x - 2, & x > 0 \end{cases}$

12.  $f(x) = \begin{cases} e^x - 1, & x \leq 0 \\ x^2, & x > 0 \end{cases}$

13.  $f(x) = \begin{cases} \frac{x^2 - 1}{x + 1}, & x < -1 \\ 2x, & x > -1 \end{cases}$

14.  $f(x) = \begin{cases} \frac{x^2 - 1}{x + 1}, & x < -1 \\ 2x, & x \geq -1 \end{cases}$

## 32.1 Answer Key

1. Discontinuous; Not defined at  $x = -11$
2. Continuous
3. Discontinuous; Left- and right-hand limits are not equal, nor do they equal the function value at  $x = -4$
4. Discontinuous; Not defined at  $x = 2$
5. Discontinuous; Left- and right-hand limits are not equal
6. Continuous
7. Discontinuous at  $x = 0, -6$
8. Discontinuous at  $x = 3$
9. Discontinuous at  $x = 1$
10. Discontinuous at  $x = \pm 3$
11. Discontinuous at  $x = 0$
12. Continuous for all values of  $x$
13. Discontinuous at  $x = -1$
14. Continuous for all values of  $x$

# Chapter 33

## Derivatives

Use the definition of the derivative to find the derivative of each function with respect to  $x$ .

1.  $f(x) = x^2 + 2x + 4$
2.  $f(x) = -5x + 5$
3.  $f(x) = 2x^2 - 5x - 2$
4.  $f(x) = 5x + 2$
5.  $f(x) = x^3 - x^2$
6.  $f(x) = 5x^2 + 5$
7.  $f(x) = 2x + 3$
8.  $f(x) = x^2 - 2$
9.  $f(x) = -5x^3 + 4$
10.  $f(x) = -4x^2 + x - 5$
11.  $f(x) = 2x^2 - 3x + 5$



## 33.1 Answer Key

1.  $2x + 2$
2.  $-5$
3.  $4x - 5$
4.  $5$
5.  $3x^2 - 2x$
6.  $10x$
7.  $2$
8.  $2x$
9.  $-15x^2$
10.  $-8x + 1$
11.  $4x - 3$

# Appendix A

## Factoring

Factor each of the following completely.

1.  $x^2 + 2x - 15$

2.  $x^2 - 8x + 12$

3.  $x^2 + 15x + 56$

4.  $5x^2 + 19x - 4$

5.  $4x^2 - 5x - 6$

6.  $9x^2 - 400$

7.  $5x^2 - 7x - 6$

8.  $9x^2 - 54x + 45$

9.  $3x^3 + 12x^2 + 9x$

10.  $9y^2 - 16$

11.  $4x^2 - 28x + 49$

12.  $14x^2 + 11xy - 15y^2$

13.  $6x^2 - 48x - 120$

14.  $9x^4 - 54x^3 + 45x^2$

15.  $16y^2 - 40y + 25$

16.  $30x^2 + xy - y^2$

17.  $8w^2 + 33w + 4$

18.  $3p^2 + 22p - 16$

19.  $18x^2 - 27x + 4$

20.  $14a^2 + 15a - 9$

21.  $4x^2 - 4x - 24$

22.  $18t^2 - 9t - 5$

23.  $6a^2 + 23a + 21$

24.  $25x^2 - 1$

## A.1 Answer Key

- |                        |                          |                        |                          |
|------------------------|--------------------------|------------------------|--------------------------|
| 1. $(x + 5)(x - 3)$    | 2. $(x - 6)(x - 2)$      | 3. $(x + 7)(x + 8)$    | 4. $(5x - 1)(x + 4)$     |
| 5. $(4x + 3)(x - 2)$   | 6. $(3x + 20)(3x - 20)$  | 7. $(5x + 3)(x - 2)$   | 8. $9(x - 5)(x - 1)$     |
| 9. $3x(x + 3)(x + 1)$  | 10. $(3y + 4)(3y - 4)$   | 11. $(2x - 7)^2$       | 12. $(7x - 5y)(2x + 3y)$ |
| 13. $6(x - 10)(x + 2)$ | 14. $9x^2(x - 1)(x - 5)$ | 15. $(4y - 5)^2$       | 16. $(6x - y)(5x + y)$   |
| 17. $(8w + 1)(w + 4)$  | 18. $(3p - 2)(p + 8)$    | 19. $(6x - 1)(3x - 4)$ | 20. $(7a - 3)(2a + 3)$   |
| 21. $4(x - 3)(x + 2)$  | 22. $(6t - 5)(3t + 1)$   | 23. $(2a + 3)(3a + 7)$ | 24. $(5x + 1)(5x - 1)$   |

# Appendix B

## Complex Fractions

Simplify each as much as possible.

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

$$2. \frac{\frac{1}{x} + \frac{2}{x^2}}{x + \frac{8}{x^2}}$$

$$3. \frac{3}{2 - \frac{x}{x-1}}$$

$$4. \frac{1 + \frac{3}{x}}{\frac{2}{x} + 7}$$

$$5. \frac{\frac{4}{x} - \frac{x}{x-2}}{\frac{1}{x} + \frac{3}{x-2}}$$

$$6. \frac{\frac{3}{x+1} - 4}{\frac{2}{x+1}}$$

$$7. \frac{\frac{5}{x} + \frac{3}{x-2}}{\frac{7}{x^2-2x}}$$

$$8. \frac{\frac{1}{x} - \frac{1}{7}}{x - 7}$$

$$9. \frac{\frac{1}{x} + \frac{1}{x+1}}{5}$$

$$10. \frac{\frac{5}{x} - 5x}{x - 1}$$

$$11. \frac{\frac{1}{2+x} - \frac{1}{2}}{x}$$

$$12. \frac{\frac{3}{x-4} + \frac{2x}{x+1}}{4x}$$

$$13. \frac{\frac{1}{x-a} + \frac{1}{a}}{x}$$

$$14. \frac{\frac{1}{x-1} - \frac{1}{x-3}}{\frac{2}{x-1} + \frac{3}{x+1}}$$

$$15. \frac{\frac{2}{x^2-4} + \frac{1}{x-2}}{\frac{4}{x+2}}$$

## B.1 Answer Key

1.  $\frac{2(5x+3)}{x(2x-1)}$

2.  $\frac{1}{x^2-2x+4}$

3.  $\frac{3(x-1)}{x-2}$

4.  $\frac{x+3}{2+7x}$

5.  $\frac{-1(x^2-4x+8)}{2(2x-1)}$

6.  $\frac{-4x-1}{2}$

7.  $\frac{8x-10}{7}$

8.  $-\frac{1}{7x}$

9.  $\frac{2x+1}{5x(x+1)}$

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

11.  $\frac{-1}{2x+4}$

12.  $\frac{(x-1)(2x-3)}{4x(x-4)(x+1)}$

13.  $\frac{1}{a(x-a)}$

14.  $\frac{-2x-2}{5x^2-16x+3}$

15.  $\frac{x+4}{4x-8}$