Precalculus

An Investigation of Functions

Exercise Sets Only
The text is available as a separate volume

1st Edition

David Lippman
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This book is also available to read free online at
http://www.opentextbookstore.com/precalc/
If you want a printed copy, buying from the bookstore is cheaper than printing yourself.

About the Authors

David Lippman received his master's degree in mathematics from Western Washington University and has been teaching at Pierce College since Fall 2000.

Melonie Rasmussen also received her master's degree in mathematics from Western Washington University and has been teaching at Pierce College since Fall 2002. Prior to this Melonie taught for the Puyallup School district for 6 years after receiving her teaching credentials from Pacific Lutheran University.

We have both been long time advocates of open learning, open materials, and basically any idea that will reduce the cost of education for students. It started by supporting the college's calculator rental program, and running a book loan scholarship program. Eventually the frustration with the escalating costs of commercial text books and the online homework systems that charged for access led them to take action.

First, David developed IMathAS, open source online math homework software that runs WAMAP.org and MyOpenMath.com. Through this platform, we became integral parts of a vibrant sharing and learning community of teachers from around Washington State that support and contribute to WAMAP. Our pioneering efforts, supported by dozens of other dedicated faculty and financial support from the Transition Math Project, have led to a system used by thousands of students every quarter, saving hundreds of thousands of dollars over comparable commercial offerings.

David continued further and wrote his first open textbook, *Math in Society*, a math for liberal arts majors book, after being frustrated by students having to pay $100+ for a textbook for a terminal course. Together, frustrated by both cost and the style of commercial texts, we began writing *PreCalculus: An Investigation of Functions* in 2010.

Acknowledgements

We would like to thank the following for their generous support and feedback.

- The community of WAMAP users and developers for creating a majority of the homework content used in our online homework sets.

- Pierce College students in our Fall 2010 - Summer 2011 Math 141 and Math 142 classes for helping correct typos, identifying videos related to the homework, and being our willing test subjects.

- The Open Course Library Project for providing the support needed to produce a full course package for these courses.

- Tophe Anderson, Chris Willett, and Vauhn Foster-Grahler for reviewing the course and giving feedback and suggestions.

- Our Pierce College colleagues for providing their suggestions.

- Tophe Anderson, James Gray, and Lawrence Morales for their feedback and suggestions in content and examples.

- Kevin Dimond for his work on indexing the book and creating PowerPoint slides.

Preface

Over the years, when reviewing books we found that many had been mainstreamed by the publishers in an effort to appeal to everyone, leaving them with very little character. There were only a handful of books that had the conceptual and application driven focus we liked, and most of those were lacking in other aspects we cared about, like providing students sufficient examples and practice of basic skills. The largest frustration, however, was the never ending escalation of cost and being forced into new editions every three years. We began researching open textbooks, however the ability for those books to be adapted, remixed, or printed were often limited by the types of licenses, or didn't approach the material the way we wanted.

This book is available online for free, in both Word and PDF format. You are free to change the wording, add materials and sections or take them away. We welcome feedback, comments and suggestions for future development at (insert an email address here). Additionally, if you add a section, chapter or problems, we would love to hear from you and possibly add your materials so everyone can benefit.

In writing this book, our focus was on the story of functions. We begin with function notation, a basic toolkit of functions, and the basic operation with functions: composition and transformation. Building from these basic functions, as each new family of functions is introduced we explore the important features of the function: its graph, domain and range, intercepts, and asymptotes. The exploration then moves to evaluating and solving equations involving the function, finding inverses, and culminates with modeling using the function.

The "rule of four" is integrated throughout - looking at the functions verbally, graphically, numerically, as well as algebraically. We feel that using the "rule of four" gives students the tools they need to approach new problems from various angles. Often the "story problems of life" do not always come packaged in a neat equation. Being able to think critically, see the parts and build a table or graph a trend, helps us change the words into meaningful and measurable functions that model the world around us.

There is nothing we hate more than a chapter on exponential equations that begins "Exponential functions are functions that have the form $f(x)=a^x$." As each family of functions is introduced, we motivate the topic by looking at how the function arises from life scenarios or from modeling. Also, we feel it is important that precalculus be the bridge in level of thinking between algebra and calculus. In algebra, it is common to see numerous examples with very similar homework exercises, encouraging the student to mimic the examples. Precalculus provides a link that takes students from the basic plug & chug of formulaic calculations towards building an understanding that equations and formulas have deeper meaning and purpose. While you will find examples and similar exercises for the basic skills in this book, you will also find examples of multistep problem solving along with exercises in multistep problem solving. Often times these exercises will not exactly mimic the exercises, forcing the students to employ their critical thinking skills and apply the skills they've learned to new situations. By

developing students' critical thinking and problem solving skills this course prepares students for the rigors of Calculus.

While we followed a fairly standard ordering of material in the first half of the book, we took some liberties in the trig portion of the book. It is our opinion that there is no need to separate unit circle trig from triangle trig, and instead integrated them in the first chapter. Identities are introduced in the first chapter, and revisited throughout. Likewise, solving is introduced in the second chapter and revisited more extensively in the third chapter. As with the first part of the book, an emphasis is placed on motivating the concepts and on modeling and interpretation.

Supplements

Spring 2010, the Washington Open Course Library (OCL) project was announced with the goal of creating open courseware for the 81 highest enrolled community college courses with a price cap on course materials of $30. We were chosen to work on precalculus for this project, and that helped drive us to complete our book, and allowed us to create supplemental materials.

A course package is available that contains the following features:

- Suggested syllabus
- Day by day course guide
- Instructor guide with lecture outlines and examples
- Additional online resources, with links to other textbooks, videos, and other resources
- Discussion forums
- Diagnostic review
- Online homework for each section (algorithmically generated, free response)
- A list of videos related to the online homework
- Printable class worksheets, activities, and handouts
- Chapter review problems
- Sample quizzes
- Sample chapter exams

The course shell was built for the IMathAS online homework platform, and is available for Washington State faculty at www.wamap.org and mirrored for others at www.myopenmath.com.

The course shell was designed to follow Quality Matters (QM) guidelines, but has not yet been formally reviewed.

How To Be Successful In This Course

This is not a high school math course, although for some of you the content may seem familiar. There are key differences to what you will learn here, how quickly you will be required to learn it and how much work will be required of you.

You will no longer be shown a technique and be asked to mimic it repetitively as the only way to prove learning. Not only will you be required to master the technique, but you will also be required to extend that knowledge to new situations and build bridges between the material at hand and the next topic, making the course highly cumulative.

As a rule of thumb, for each hour you spend in class, you should expect this course will require an average of 2 hours of out of class focused study. This means that some of you with a stronger background in mathematics may take less, but if you have a weaker background or any math anxiety it will take you more.

Notice how this is the equivalent of having a part time job, and if you are taking a fulltime load of courses as many college students do, this equates to more than a full time job.   If you must work, raise a family and take a full load of courses all at the same time, we recommend that you get a head start & get organized as soon as possible. We also recommend that you spread out your learning into daily chunks and avoid trying to cram or learn material quickly before an exam.

To be prepared, read through the material before it is covered in and note or highlight the material that is new or confusing. The instructor's lecture and activities should not be the first exposure to the material. As you read, test your understanding with the Try it Now problems in the book. If you can't figure one out, try again after class, and ask for help if you still can't get it.

As soon as possible after the class session recap the days lecture or activities into a meaningful format to provide a third exposure to the material. You could summarize your notes into a list of key points, or reread your notes and try to work examples done in class without referring back to your notes. Next, begin any assigned homework. The next day, if the instructor provides the opportunity to clarify topics or ask questions, do not be afraid to ask. If you are afraid to ask, then you are not getting your money's worth! If the instructor does not provide this opportunity, be prepared to go to a tutoring center or build a peer study group. Put in quality effort and time and you can get quality results.

Lastly, if you feel like you do not understand a topic. Don't wait, ASK FOR HELP!

ASK: Ask a teacher or tutor, **S**earch for ancillaries, **K**eep a detailed list of questions
FOR: Find additional resources, **O**rganize the material, **R**esearch other learning options
HELP: Have a support network, **E**xamine your weaknesses, **L**ist specific examples & **P**ractice

Best of luck learning! We hope you like the course & love the price.
David & Melonie

Table of Contents

Section 1.1 Exercises

1. The amount of garbage, G, produced by a city with population p is given by
    $G = f(p)$. G is measured in tons per week, and p is measured in thousands of people.
   a. The town of Tola has a population of 40,000 and produces 13 tons of garbage
        each week. Express this information in terms of the function f.
    b. Explain the meaning of the statement $f(5) = 2$

2. The number of cubic yards of dirt, D, needed to cover a garden with area a square
    feet is given by $D = g(a)$.
    a. A garden with area 5000 ft^2 requires 50 cubic yards of dirt. Express this
        information in terms of the function g.
    b. Explain the meaning of the statement $g(100) = 1$

3. Let $f(t)$ be the number of ducks in a lake t years after 1990. Explain the meaning of
    each statement:
    a. $f(5) = 30$ b. $f(10) = 40$

4. Let $h(t)$ be the height above ground, in feet, of a rocket t seconds after launching.
    Explain the meaning of each statement:
    a. $h(1) = 200$ b. $h(2) = 350$

5. Select all of the following graphs which represent y as a function of x.
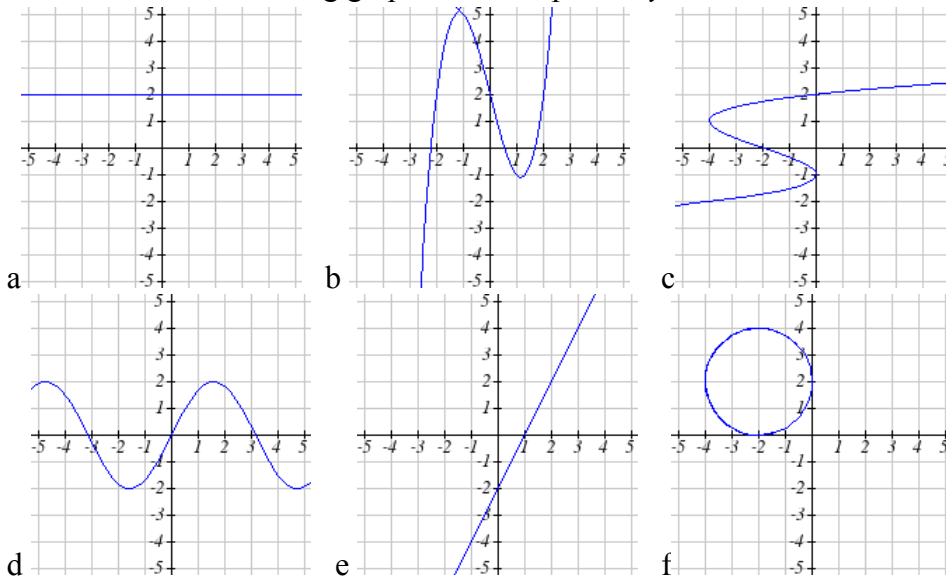
6. Select all of the following graphs which represent y as a function of x.

a

b

c

d

e

f
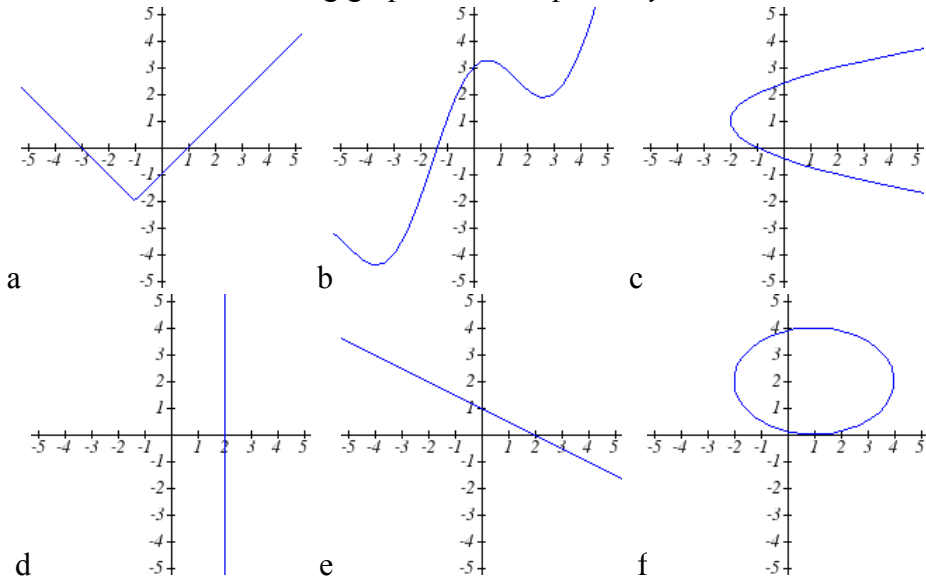
7. Select all of the following tables which represent y as a function of x.

a.

x	5	10	15
y	3	8	14

b.

x	5	10	15
y	3	8	8

c.

x	5	10	10
y	3	8	14

8. Select all of the following tables which represent y as a function of x.

a.

x	2	6	13
y	3	10	10

b.

x	2	6	6
y	3	10	14

c.

x	2	6	13
y	3	10	14

9. Select all of the following tables which represent y as a function of x.

a.

x	y
0	-2
3	1
4	6
8	9
3	1

b.

x	y
-1	-4
2	3
5	4
8	7
12	11

c.

x	y
0	-5
3	1
3	4
9	8
16	13

d.

x	y
-1	-4
1	2
4	2
9	7
12	13

10. Select all of the following tables which represent y as a function of x.

a.

x	y
-4	-2
3	2
6	4
9	7
12	16

b.

x	y
-5	-3
2	1
2	4
7	9
11	10

c.

x	y
-1	-3
1	2
5	4
9	8
1	2

d.

x	y
-1	-5
3	1
5	1
8	7
14	12

11. Select all of the following tables which represent y as a function of x **and** are one-to-one.

a.

x	3	8	12
y	4	7	7

b.

x	3	8	12
y	4	7	13

c.

x	3	8	8
y	4	7	13

12. Select all of the following tables which represent y as a function of x **and** are one-to-one.

a.

x	2	8	8
y	5	6	13

b.

x	2	8	14
y	5	6	6

c.

x	2	8	14
y	5	6	13

13. Select all of the following graphs which are **one-to-one functions**.

a.   b.   c.

d.   e.   f.
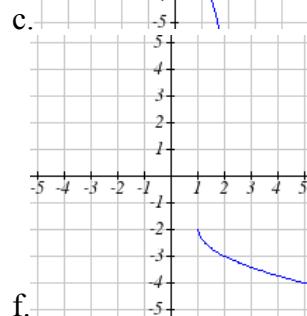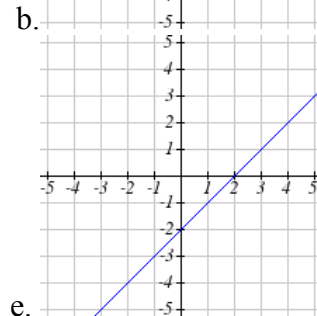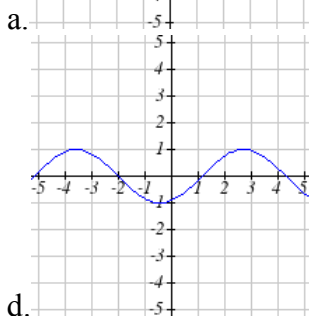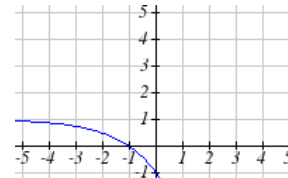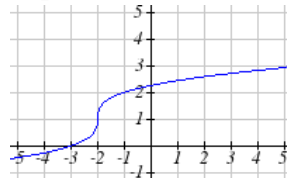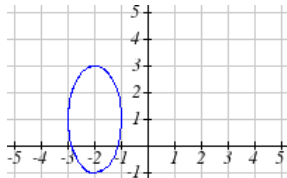
14. Select all of the following graphs which are **one-to-one functions**.

a   b   c

d   e   f
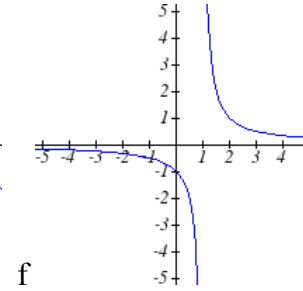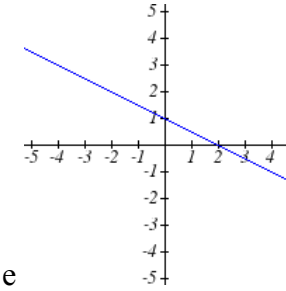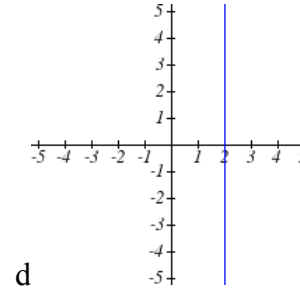
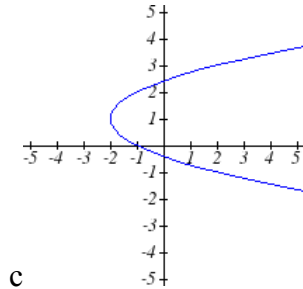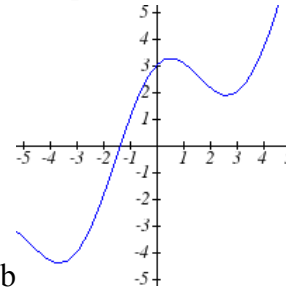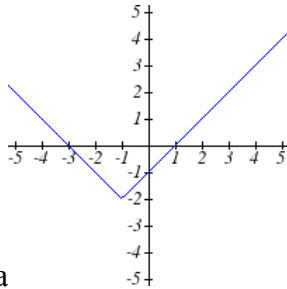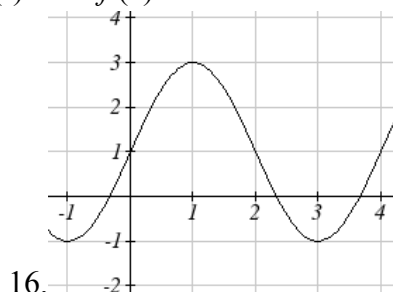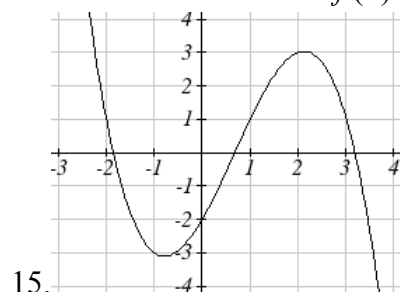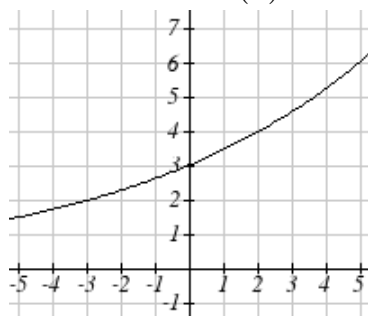Given the each function $f(x)$ graphed, evaluate $f(1)$ and $f(3)$

15.

16.

17. Given the function $g(x)$ graphed here,
    a. Evaluate $g(2)$
    b. Solve $g(x)=2$

18. Given the function $f(x)$ graphed here.
    a. Evaluate $f(4)$
    b. Solve $f(x)=4$
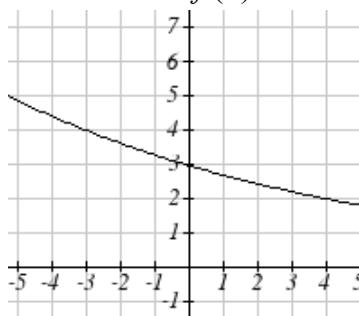
19. Based on the table below,
    a. Evaluate $f(3)$ b. Solve $f(x)=1$

x	0	1	2	3	4	5	6	7	8	9
$f(x)$	74	28	1	53	56	3	36	45	14	47

20. Based on the table below,
    a. Evaluate $f(8)$ b. Solve $f(x)=7$

x	0	1	2	3	4	5	6	7	8	9
$f(x)$	62	8	7	38	86	73	70	39	75	34

For each of the following functions, evaluate: $f(-2)$, $f(-1)$, $f(0)$, $f(1)$, and $f(2)$

21. $f(x)=4-2x$

22. $f(x)=8-3x$

23. $f(x)=8x^2-7x+3$

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

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

26. $f(x)=5x^4+x^2$

27. $f(x)=3+\sqrt{x+3}$

28. $f(x)=4-\sqrt[3]{x-2}$

29. $f(x)=(x-2)(x+3)$

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

31. $f(x)=\dfrac{x-3}{x+1}$

32. $f(x)=\dfrac{x-2}{x+2}$

33. $f(x)=2^x$

34. $f(x)=3^x$

35. Suppose $f(x) = x^2 + 8x - 4$. Compute the following:

    a. $f(-1) + f(1)$ b. $f(-1) - f(1)$

36. Suppose $f(x) = x^2 + x + 3$. Compute the following:

    a. $f(-2) + f(4)$ b. $f(-2) - f(4)$

37. Let $f(t) = 3t + 5$

    a. Evaluate $f(0)$ b. Solve $f(t) = 0$
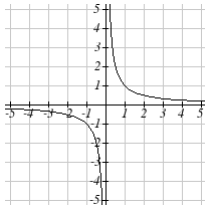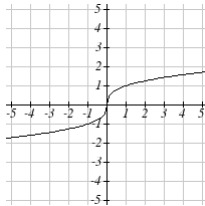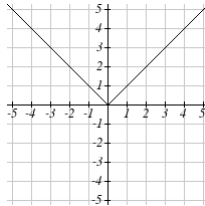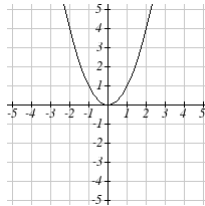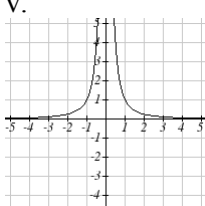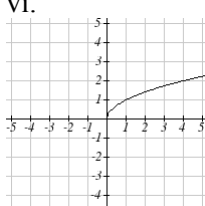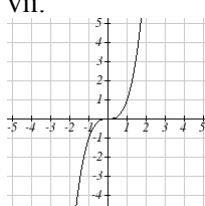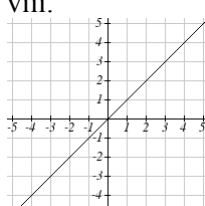
38. Let $g(p) = 6 - 2p$

    a. Evaluate $g(0)$ b. Solve $g(p) = 0$

39. Match each function name with its equation.

    a. $y = x$

    b. $y = x^3$

    c. $y = \sqrt[3]{x}$

    d. $y = \dfrac{1}{x}$

    e. $y = x^2$

    f. $y = \sqrt{x}$

    g. $y = |x|$

    h. $y = \dfrac{1}{x^2}$

    i.   Cube root

    ii.   Reciprocal

    iii.   Linear

    iv.   Square Root

    v.   Absolute Value

    vi.   Quadratic

    vii.   Reciprocal Squared

    viii.   Cubic

40. Match each graph with its equation.

    a. $y = x$

    b. $y = x^3$

    c. $y = \sqrt[3]{x}$

    d. $y = \dfrac{1}{x}$

    e. $y = x^2$

    f. $y = \sqrt{x}$

    g. $y = |x|$

    h. $y = \dfrac{1}{x^2}$

41. Match each table with its equation.

    a. $y = x^2$
    b. $y = x$
    c. $y = \sqrt{x}$
    d. $y = 1/x$
    e. $y = |x|$
    f. $y = x^3$

    i.
In	Out
-2	-0.5
-1	-1
0	
1	1
2	0.5
3	0.33

    ii.
In	Out
-2	-2
-1	-1
0	0
1	1
2	2
3	3

    iii.
In	Out
-2	-8
-1	-1
0	0
1	1
2	8
3	27

    iv.
In	Out
-2	4
-1	1
0	0
1	1
2	4
3	9

    v.
In	Out
-2	
-1	
0	0
1	1
4	2
9	3

    vi.
In	Out
-2	2
-1	1
0	0
1	1
2	2
3	3

42. Match each equation with its table

    a. Quadratic
    b. Absolute Value
    c. Square Root
    d. Linear
    e. Cubic
    f. Reciprocal

    i.
In	Out
-2	-0.5
-1	-1
0	
1	1
2	0.5
3	0.33

    ii.
In	Out
-2	-2
-1	-1
0	0
1	1
2	2
3	3

    iii.
In	Out
-2	-8
-1	-1
0	0
1	1
2	8
3	27

    iv.
In	Out
-2	4
-1	1
0	0
1	1
2	4
3	9

    v.
In	Out
-2	
-1	
0	0
1	1
4	2
9	3

    vi.
In	Out
-2	2
-1	1
0	0
1	1
2	2
3	3

43. Write the equation of the circle centered at $(3, -9)$ with radius 6.

44. Write the equation of the circle centered at $(9, -8)$ with radius 11.

45. Sketch a reasonable graph for each of the following functions. [UW]
    a. Height of a person depending on age.
    b. Height of the top of your head as you jump on a pogo stick for 5 seconds.
    c. The amount of postage you must put on a first class letter, depending on the weight of the letter.

46. Sketch a reasonable graph for each of the following functions. [UW]
    a. Distance of your big toe from the ground as you ride your bike for 10 seconds.
    b. You height above the water level in a swimming pool after you dive off the high board.
    c. The percentage of dates and names you'll remember for a history test, depending on the time you study
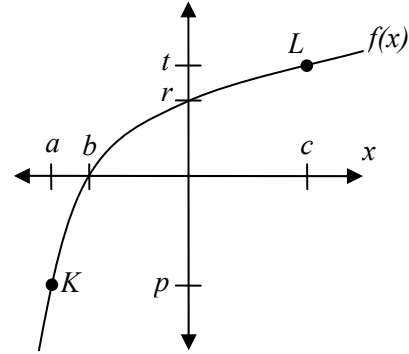
47. Using the graph shown,
    a. Evaluate $f(c)$
    b. Solve $f(x) = p$
    c. Suppose $f(b) = z$. Find $f(z)$
    d. What are the coordinates of points L and K?

48. Dave leaves his office in Padelford Hall on his way to teach in Gould Hall. Below are several different scenarios. In each case, sketch a plausible (reasonable) graph of the function s = d(t) which keeps track of Dave's distance s from Padelford Hall at time t. Take distance units to be "feet" and time units to be "minutes." Assume Dave's path to Gould Hall is long a straight line which is 2400 feet long. [UW]
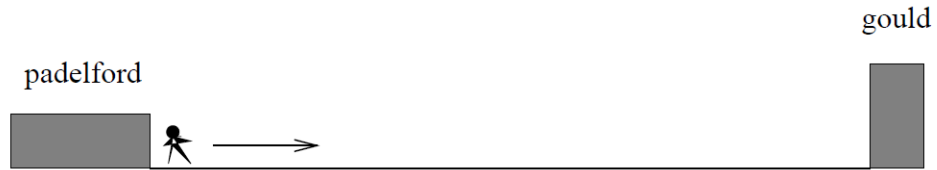
    a. Dave leaves Padelford Hall and walks at a constant spend until he reaches Gould Hall 10 minutes later.

    b. Dave leaves Padelford Hall and walks at a constant speed. It takes him 6 minutes to reach the half-way point. Then he gets confused and stops for 1 minute. He then continues on to Gould Hall at the same constant speed he had when he originally left Padelford Hall.

    c. Dave leaves Padelford Hall and walks at a constant speed. It takes him 6 minutes to reach the half-way point. Then he gets confused and stops for 1 minute to figure out where he is. Dave then continues on to Gould Hall at twice the constant speed he had when he originally left Padelford Hall.

d. Dave leaves Padelford Hall and walks at a constant speed. It takes him 6 minutes to reach the half-way point. Then he gets confused and stops for 1 minute to figure out where he is. Dave is totally lost, so he simply heads back to his office, walking the same constant speed he had when he originally left Padelford Hall.

e. Dave leaves Padelford heading for Gould Hall at the same instant Angela leaves Gould Hall heading for Padelford Hall. Both walk at a constant speed, but Angela walks twice as fast as Dave. Indicate a plot of "distance from Padelford" vs. "time" for the both Angela and Dave.

f. Suppose you want to sketch the graph of a new function $s = g(t)$ that keeps track of Dave's distance s from Gould Hall at time t. How would your graphs change in (a)-(e)?

Section 1.2 Exercises

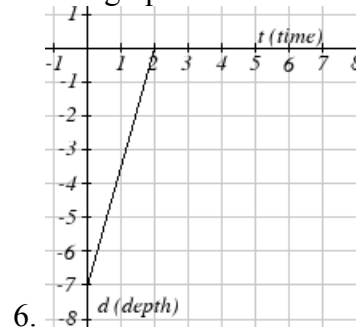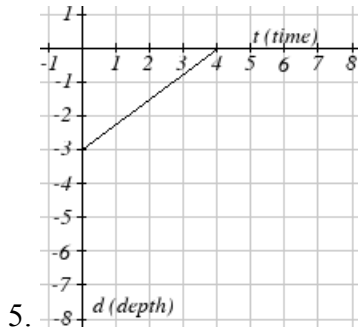Write the domain and range of the function using interval notation.

1.

2.
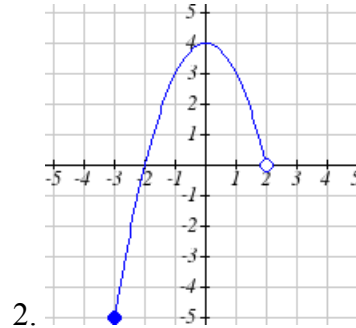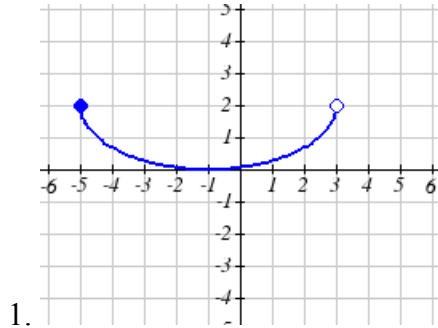
Write the domain and range of each graph as an inequality.

3.

4.
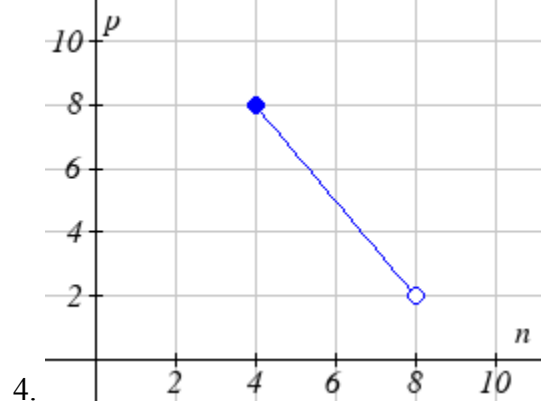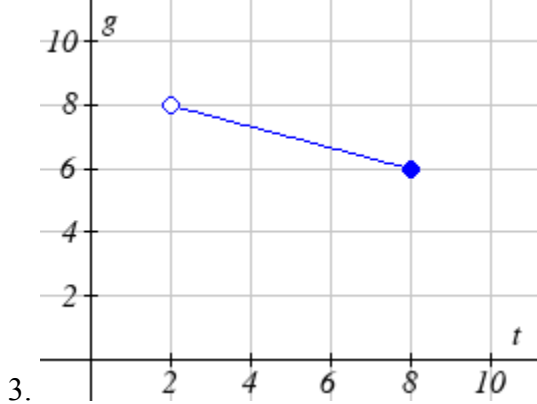
Suppose that you are holding your toy submarine under the water. You release it and it begins to ascend. The graph models the depth of the submarine as a function of time. What is the domain and range of the function in the graph?

5.

6.

10 Chapter 1

Find the domain of each function

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

8. $f(x) = 5\sqrt{x+3}$

9. $f(x) = 3 - \sqrt{6-2x}$

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

11. $f(x) = \dfrac{9}{x-6}$

12. $f(x) = \dfrac{6}{x-8}$

13. $f(x) = \dfrac{3x+1}{4x+2}$

14. $f(x) = \dfrac{5x+3}{4x-1}$

15. $f(x) = \dfrac{\sqrt{x+4}}{x-4}$

16. $f(x) = \dfrac{\sqrt{x+5}}{x-6}$

17. $f(x) = \dfrac{x-3}{x^2+9x-22}$

18. $f(x) = \dfrac{x-8}{x^2+8x-9}$

Given each function, evaluate: $f(-1)$, $f(0)$, $f(2)$, $f(4)$

19. $f(x) = \begin{cases} 7x+3 & if \quad x < 0 \\ 7x+6 & if \quad x \geq 0 \end{cases}$

20. $f(x) = \begin{cases} 4x-9 & if \quad x < 0 \\ 4x-18 & if \quad x \geq 0 \end{cases}$

21. $f(x) = \begin{cases} x^2-2 & if \quad x < 2 \\ 4+|x-5| & if \quad x \geq 2 \end{cases}$

22. $f(x) = \begin{cases} 4-x^3 & if \quad x < 1 \\ \sqrt{x+1} & if \quad x \geq 1 \end{cases}$

23. $f(x) = \begin{cases} 5x & if \quad x < 0 \\ 3 & if \quad 0 \leq x \leq 3 \\ x^2 & if \quad x > 3 \end{cases}$

24. $f(x) = \begin{cases} x^3+1 & if \quad x < 0 \\ 4 & if \quad 0 \leq x \leq 3 \\ 3x+1 & if \quad x > 3 \end{cases}$

Write a formula for the piecewise function graphed below.

25.

26.

27.

28.

29.

30.
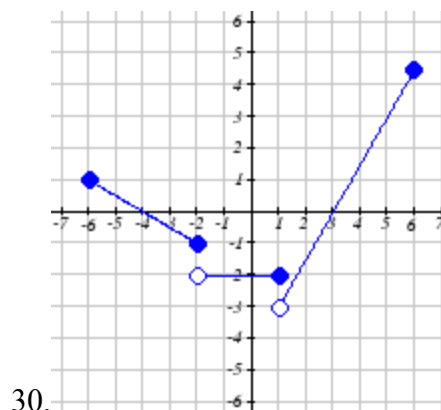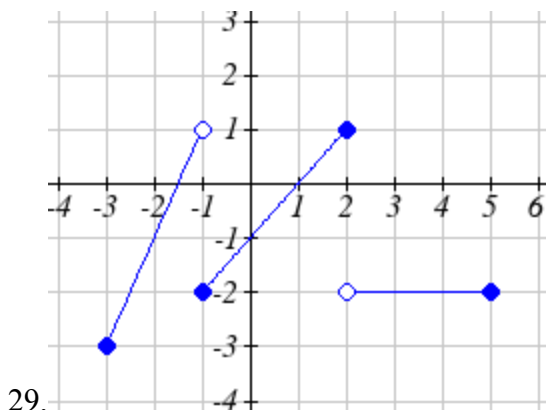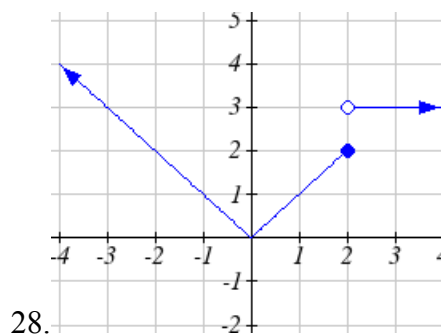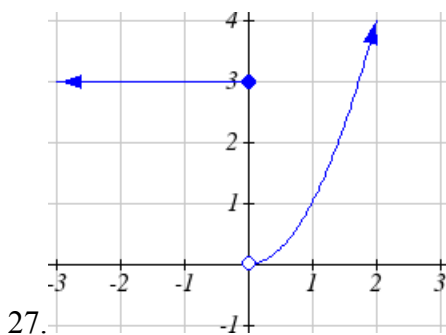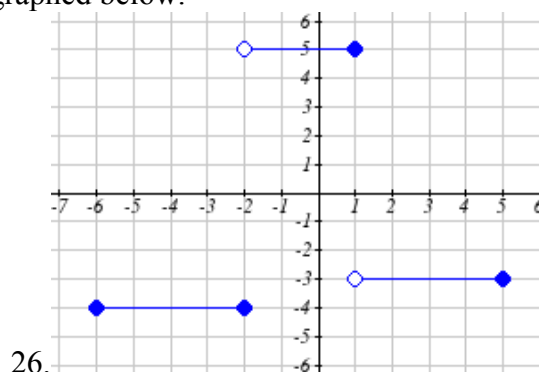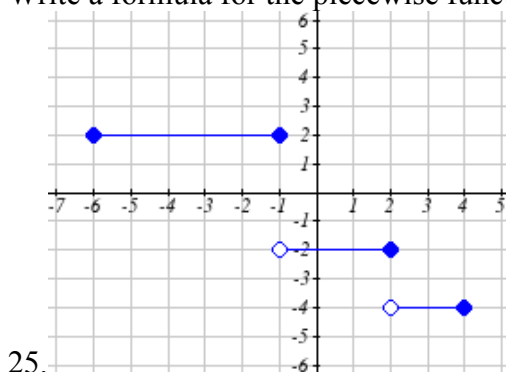
Sketch a graph of each piecewise function

31. $f(x) = \begin{cases} |x| & if \quad x < 2 \\ 5 & if \quad x \geq 2 \end{cases}$

32. $f(x) = \begin{cases} 4 & if \quad x < 0 \\ \sqrt{x} & if \quad x \geq 0 \end{cases}$

33. $f(x) = \begin{cases} x^2 & if \quad x < 0 \\ x+2 & if \quad x \geq 0 \end{cases}$

34. $f(x) = \begin{cases} x+1 & if \quad x < 1 \\ x^3 & if \quad x \geq 1 \end{cases}$

35. $f(x) = \begin{cases} 3 & if \quad x \leq -2 \\ -x+1 & if \quad -2 < x \leq 1 \\ 3 & if \quad x > 1 \end{cases}$

36. $f(x) = \begin{cases} -3 & if \quad x \leq -2 \\ x-1 & if \quad -2 < x \leq 2 \\ 0 & if \quad x > 2 \end{cases}$

Section 1.3 Exercises

1. The table below gives the annual sales (in millions of dollars) of a product. What was the average rate of change of annual sales…
    a) Between 2001 and 2002   b) Between 2001 and 2004

| year	1998	1999	2000	2001	2002	2003	2004	2005	2006
sales	201	219	233	243	249	251	249	243	233

2. The table below gives the population of a town, in thousands. What was the average rate of change of population…
    a) Between 2002 and 2004   b) Between 2002 and 2006

year	2000	2001	2002	2003	2004	2005	2006	2007	2008
population	87	84	83	80	77	76	75	78	81

3. Based on the graph shown, estimate the average rate of change from $x = 1$ to $x = 4$.

4. Based on the graph shown, estimate the average rate of change from $x = 2$ to $x = 5$.
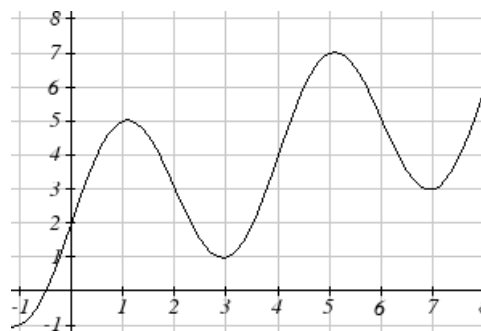
Find the average rate of change of each function on the interval specified.

5. $f(x) = x^2$ on [1, 5]

6. $q(x) = x^3$ on [-4, 2]

7. $g(x) = 3x^3 - 1$ on [-3, 3]

8. $h(x) = 5 - 2x^2$ on [-2, 4]

9. $k(t) = 6t^2 + \dfrac{4}{t^3}$ on [-1, 3]

10. $p(t) = \dfrac{t^2 - 4x + 1}{t^2 + 3}$ on [-3, 1]

Find the average rate of change of each function on the interval specified. Your answers will be expressions.

11. $f(x) = 4x^2 - 7$ on [1, b]

12. $g(x) = 2x^2 - 9$ on [4, b]

13. $h(x) = 3x + 4$ on [2, 2+h]

14. $k(x) = 4x - 2$ on [3, 3+h]

15. $a(t) = \dfrac{1}{t + 4}$ on [9, 9+h]

16. $b(x) = \dfrac{1}{x + 3}$ on [1, 1+h]
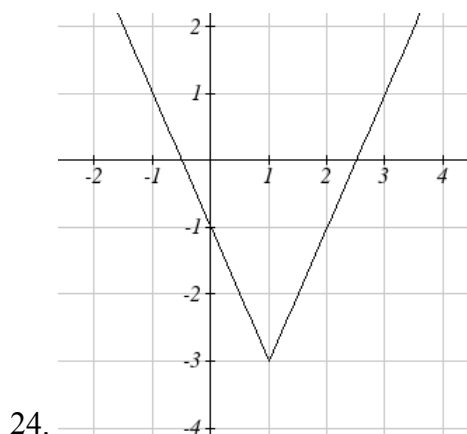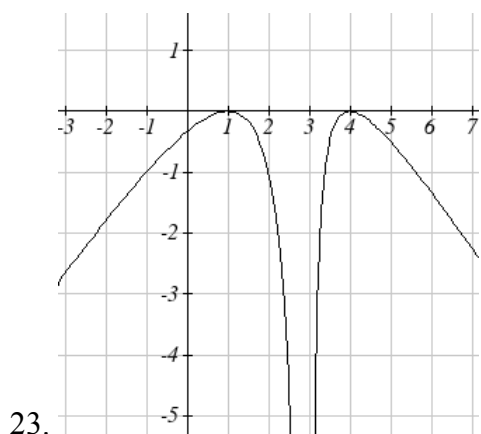
17. $j(x) = 3x^3$ on [1, 1+h]

18. $r(t) = 4t^3$ on [2, 2+h]

19. $f(x) = 2x^2 + 1$ on [x, x+h]

20. $g(x) = 3x^2 - 2$ on [x, x+h]

For each function graphed, estimate the intervals on which the function is increasing and decreasing.

21.

22.

23.

24.
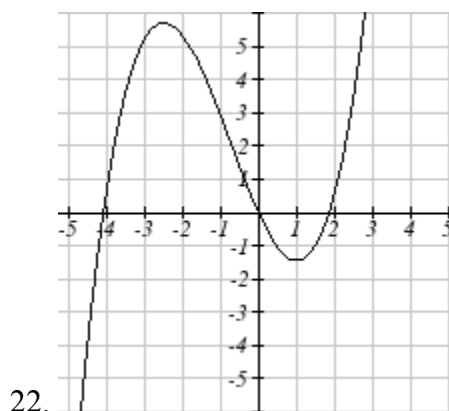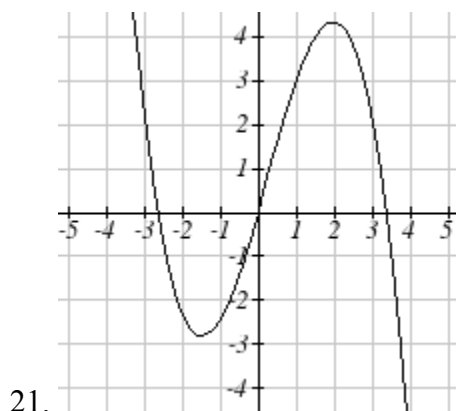
For each table below, select whether the table represents a function that is increasing or decreasing, and whether the function is concave up or concave down.

25.

x	f(x)
1	2
2	4
3	8
4	16
5	32

26.

x	g(x)
1	90
2	70
3	80
4	75
5	72

27.

x	h(x)
1	300
2	290
3	270
4	240
5	200

28.

x	k(x)
1	0
2	15
3	25
4	32
5	35

29.

x	f(x)
1	-10
2	-25
3	-37
4	-47
5	-54

30.

x	g(x)
1	-200
2	-190
3	-160
4	-100
5	0

31.

x	h(x)
1	-100
2	-50
3	-25
4	-10
5	0

32.

x	k(x)
1	-50
2	-100
3	-200
4	-400
5	-900

For each function graphed, estimate the intervals on which the function is concave up and concave down, and the location of any inflection points.

33.

34.

35.

36.
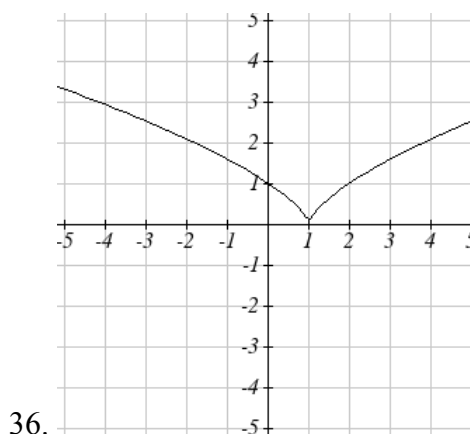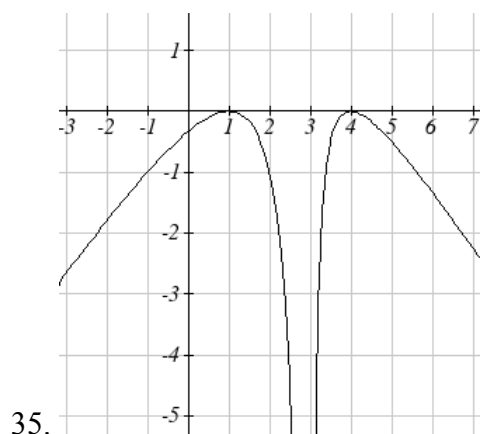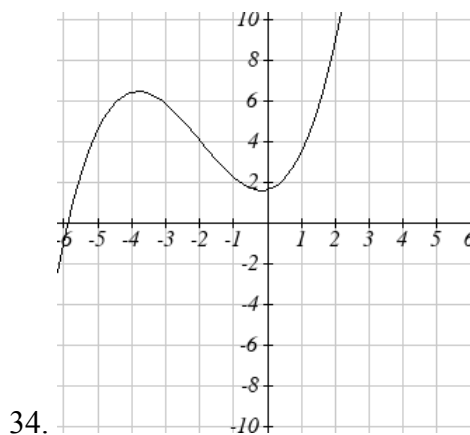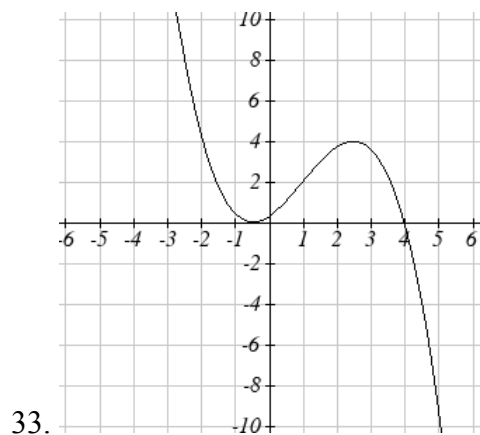
Use a graph to estimate the local extrema and inflection points of each function, and to estimate the intervals on which the function is increasing, decreasing, concave up, and concave down.

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

38. $h(x) = x^5 + 5x^4 + 10x^3 + 10x^2 - 1$

39. $g(t) = t\sqrt{t+3}$

40. $k(t) = 3t^{2/3} - t$

41. $m(x) = x^4 + 2x^3 - 12x^2 - 10x + 4$

42. $n(x) = x^4 - 8x^3 + 18x^2 - 6x + 2$

Section 1.4 Exercises

Given each pair of equations, calculate $f(g(0))$ and $g(f(0))$

1. $f(x) = 4x + 8$, $g(x) = 7 - x^2$

2. $f(x) = 5x + 7$, $g(x) = 4 - 2x^2$

3. $f(x) = \sqrt{x+4}$, $g(x) = 12 - x^3$

4. $f(x) = \dfrac{1}{x+2}$, $g(x) = 4x + 3$

Use the table of values to evaluate each expression

5. $f(g(8))$

6. $f(g(5))$

7. $g(f(5))$

8. $g(f(3))$

9. $f(f(4))$

10. $f(f(1))$

11. $g(g(2))$

12. $g(g(6))$

x	$f(x)$	$g(x)$
0	7	9
1	6	5
2	5	6
3	8	2
4	4	1
5	0	8
6	2	7
7	1	3
8	9	4
9	3	0

Use the graphs to evaluate the expressions below.

13. $f(g(3))$

14. $f(g(1))$

15. $g(f(1))$

16. $g(f(0))$
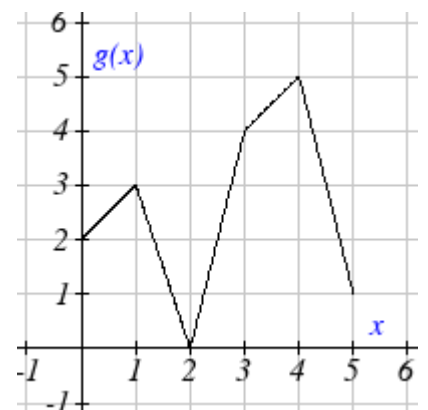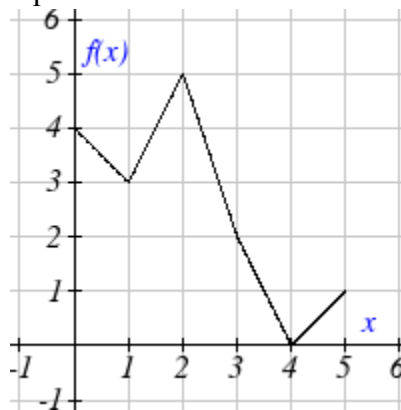
17. $f(f(5))$

18. $f(f(4))$

19. $g(g(2))$

20. $g(g(0))$

For each pair of functions, find $f(g(x))$ and $g(f(x))$. Simplify your answers.

21. $f(x) = \dfrac{1}{x-6}$, $g(x) = \dfrac{7}{x} + 6$

22. $f(x) = \dfrac{1}{x-4}$, $g(x) = \dfrac{2}{x} + 4$

23. $f(x) = x^2 + 1$, $g(x) = \sqrt{x+2}$

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

25. $f(x)=|x|$, $g(x)=5x+1$ 26. $f(x)=\sqrt[3]{x}$, $g(x)=\dfrac{x+1}{x^3}$

27. If $f(x)=x^4+6$, $g(x)=x-6$ and $h(x)=\sqrt{x}$, find $f(g(h(x)))$

28. If $f(x)=x^2+1$, $g(x)=\dfrac{1}{x}$ and $h(x)=x+3$, find $f(g(h(x)))$

29. Given functions $p(x)=\dfrac{1}{\sqrt{x}}$ and $m(x)=x^2-4$, state the domains of the following functions using interval notation.

    a. Domain of $\dfrac{p(x)}{m(x)}$

    b. Domain of $p(m(x))$

    c. Domain of $m(p(x))$

30. Given functions $q(x)=\dfrac{1}{\sqrt{x}}$ and $h(x)=x^2-9$, state the domains of the following functions using interval notation.

    a. Domain of $\dfrac{q(x)}{h(x)}$

    b. Domain of $q(h(x))$

    c. Domain of $h(q(x))$

31. The function $D(p)$ gives the number of items that will be demanded when the price is p. The production cost, $C(x)$ is the cost of producing x items. To determine the cost of production when the price is $6, you would do which of the following:
    a. Evaluate $D(C(6))$ b. Evaluate $C(D(6))$
    c. Solve $D(C(x))=6$ d. Solve $C(D(p))=6$

32. The function $A(d)$ gives the pain level on a scale of 0-10 experienced by a patient with d milligrams of a pain reduction drug in their system. The milligrams of drug in the patient's system after t minutes is modeled by $m(t)$. To determine when the patient will be at a pain level of 4, you would need to:
    a. Evaluate $A(m(4))$ b. Evaluate $m(A(4))$
    c. Solve $A(m(t))=4$ d. Solve $m(A(d))=4$

33. The radius r, in inches, of a balloon is related to the volume, V, by $r(V) = \sqrt[3]{\dfrac{3V}{4\pi}}$. Air is pumped into the balloon, so the volume after t seconds is given by $V(t) = 10 + 20t$

    a. Find the composite function $r(V(t))$

    b. Find the time when the radius reaches 10 inches.

34. The number of bacteria in a refrigerated food product is given by $N(T) = 23T^2 - 56T + 1$, $3 < T < 33$ where T is the temperature of the food. When the food is removed from the refrigerator, the temperature is given by $T(t) = 5t + 1.5$, where t is the time in hours.

    a. Find the composite function $N(T(t))$

    b. Find the time when the bacteria count reaches 6752

Find functions $f(x)$ and $g(x)$ so the given function can be expressed as $h(x) = f(g(x))$

35. $h(x) = (x+2)^2$ 36. $h(x) = (x-5)^3$

37. $h(x) = \dfrac{3}{x-5}$ 38. $h(x) = \dfrac{4}{(x+2)^2}$

39. $h(x) = 3 + \sqrt{x-2}$ 40. $h(x) = 4 + \sqrt[3]{x}$

41. Let $f(x)$ be a linear function, having form $f(x) = ax + b$ for constants a and b. [UW]

a. Show that $f(f(x))$ is a linear function

b. Find a function $g(x)$ such that $g(g(x)) = 6x - 8$

42. Let $f(x) = \dfrac{1}{2}x + 3$ [UW]

    a. Sketch the graphs of $f(x), f(f(x)), f(f(f(x)))$ on the interval $-2 \le x \le 10$.

    b. Your graphs should all intersect at the point (6, 6). The value x = 6 is called a fixed point of the function $f(x)$ since $f(6) = 6$; that is, 6 is fixed - it doesn't move when f is applied to it. Give an explanation for why 6 is a fixed point for any function $f(f(f(...f(x)...)))$.

    c. Linear functions (with the exception of $f(x) = x$) can have at most one fixed point. Quadratic functions can have at most two. Find the fixed points of the function $g(x) = x^2 - 2$.

    d. Give a quadratic function whose fixed points are $x = -2$ and $x = 3$.

43. A car leaves Seattle heading east. The speed of the car in mph after m minutes is given by the function $C(m) = \dfrac{70m^2}{10 + m^2}$. [UW]

   a. Find a function $m = f(s)$ that converts seconds s into minutes m. Write out the formula for the new function $C(f(s))$; what does this function calculate?

   b. Find a function $m = g(h)$ that converts hours h into minutes m. Write out the formula for the new function $C(g(h))$; what does this function calculate?

   c. Find a function $z = v(s)$ that converts mph s into ft/sec z. Write out the formula for the new function $v(C(m))$; what does this function calculate?

Section 1.5 Exercises

Describe how each function is a transformation of the original function $f(x)$

1. $f(x-49)$ 2. $f(x+43)$

3. $f(x+3)$ 4. $f(x-4)$

5. $f(x)+5$ 6. $f(x)+8$

7. $f(x)-2$ 8. $f(x)-7$

9. $f(x-2)+3$ 10. $f(x+4)-1$

11. Write a formula for $f(x)=\sqrt{x}$ shifted up 1 unit and left 2 units

12. Write a formula for $f(x)=|x|$ shifted down 3 units and right 1 unit

13. Write a formula for $f(x)=\dfrac{1}{x}$ shifted down 4 units and right 3 units

14. Write a formula for $f(x)=\dfrac{1}{x^2}$ shifted up 2 units and left 4 units

15. Tables of values for $f(x)$, $g(x)$, and $h(x)$ are given below. Write $g(x)$ and $h(x)$ as transformations of $f(x)$.

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

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

x	-2	-1	0	1	2
$h(x)$	-1	0	-2	2	3

16. Tables of values for $f(x)$, $g(x)$, and $h(x)$ are given below. Write $g(x)$ and $h(x)$ as transformations of $f(x)$.
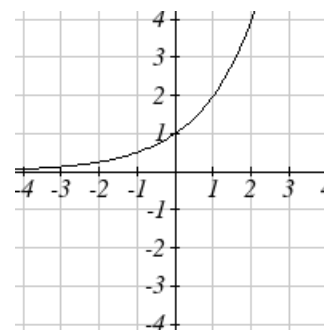
x	-2	-1	0	1	2
$f(x)$	-1	-3	4	2	1

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

x	-2	-1	0	1	2
$h(x)$	-2	-4	3	1	0

The graph of $f(x)=2^x$ is shown. Sketch a graph of each transformation of $f(x)$

17. $g(x)=2^x+1$

18. $h(x)=2^x-3$

19. $w(x)=2^{x-1}$

20. $q(x)=2^{x+3}$

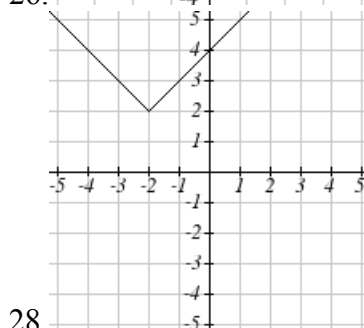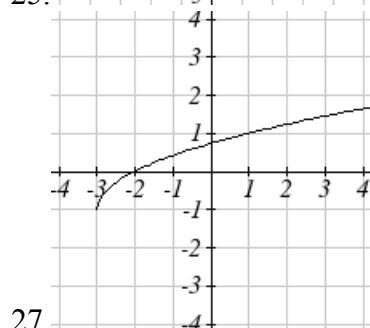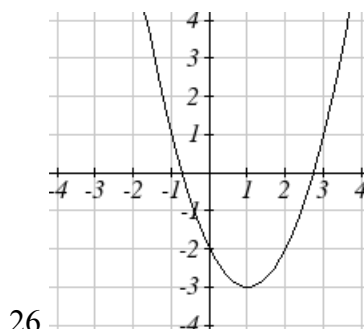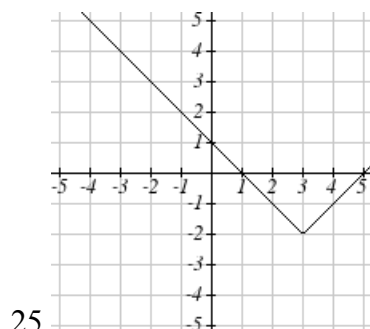Sketch a graph of each function as a transformation of a toolkit function
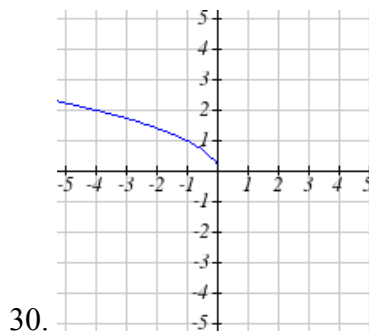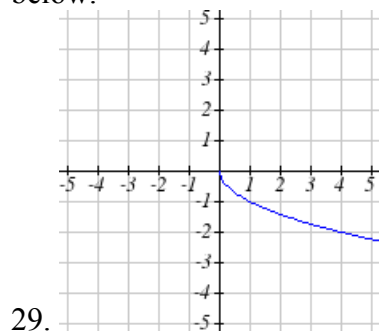
21. $f(t) = (t+1)^2 - 3$

22. $h(x) = |x-1| + 4$

23. $k(x) = (x-2)^3 - 1$
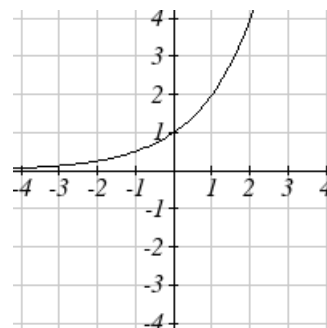
24. $m(t) = 3 + \sqrt{t+2}$

Write an equation for the function graphed below

25.

26.

27.

28.

Find a formula for each of the transformations of the square root whose graphs are given below.

29.

30.

The graph of $f(x) = 2^x$ is shown. Sketch a graph of each transformation of $f(x)$

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

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

33. Starting with the graph of $f(x) = 6^x$ write the equation of the graph that results from
    a. reflecting $f(x)$ about the x-axis and the y-axis
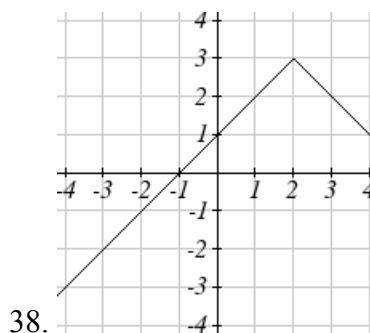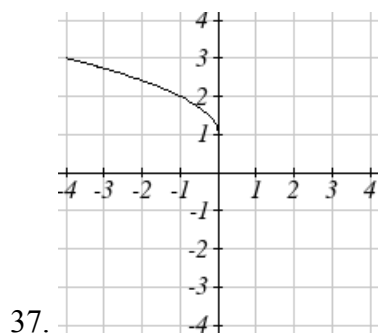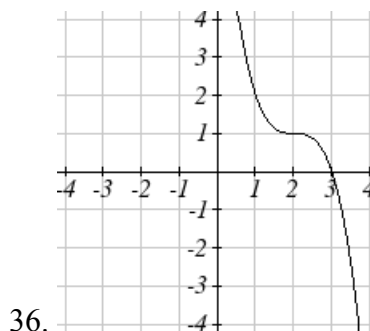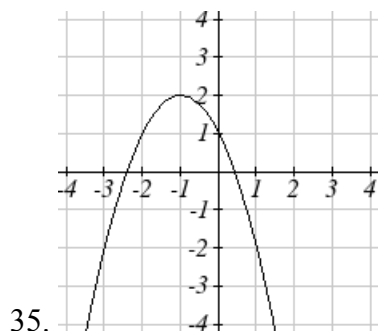   b. reflecting $f(x)$ about the x-axis, shifting left 2 units, and down 3 units

34. Starting with the graph of $f(x) = 4^x$ write the equation of the graph that results from
    a. reflecting $f(x)$ about the x-axis
    b. reflecting $f(x)$ about the y-axis, shifting right 4 units, and up 2 units

Write an equation for the function graphed below

35.

36.

37.

38.

39. For each equation below, determine if the function is Odd, Even, or Neither
    a. $f(x) = 3x^4$
    b. $g(x) = \sqrt{x}$
    c. $h(x) = \dfrac{1}{x} + 3x$

40. For each equation below, determine if the function is Odd, Even, or Neither
    a. $f(x) = (x-2)^2$
    b. $g(x) = 2x^4$
    c. $h(x) = 2x - x^3$

Describe how each function is a transformation of the original function $f(x)$

41. $-f(x)$ 42. $f(-x)$

43. $4f(x)$ 44. $6f(x)$

45. $f(5x)$ 46. $f(2x)$

47. $f\left(\dfrac{1}{3}x\right)$ 48. $f\left(\dfrac{1}{5}x\right)$

49. $3f(-x)$ 50. $-f(3x)$

51. Write a formula for $f(x) = |x|$ reflected over the y axis and horizontally compressed

    by a factor of $\dfrac{1}{4}$

52. Write a formula for $f(x) = \sqrt{x}$ reflected over the x axis and horizontally stretched by
    a factor of 2

53. Write a formula for $f(x) = \dfrac{1}{x^2}$ vertically compressed by a factor of $\dfrac{1}{3}$, then shifted to
    the left 2 units and down 3 units.

54. Write a formula for $f(x) = \dfrac{1}{x}$ vertically stretched by a factor of 8, then shifted to the
    right 4 units and up 2 units.

55. Write a formula for $f(x) = x^2$ horizontally compressed by a factor of $\dfrac{1}{2}$, then shifted
    to the right 5 units and up 1 unit.

56. Write a formula for $f(x) = x^2$ horizontally stretched by a factor of 3, then shifted to
    the left 4 units and down 3 units.

Describe how each formula is a transformation of a toolkit function. Then sketch a graph of the transformation.

57. $f(x) = 4(x+1)^2 - 5$

58. $g(x) = 5(x+3)^2 - 2$

59. $h(x) = -2|x-4| + 3$

60. $k(x) = -3\sqrt{x} - 1$

61. $m(x) = \frac{1}{2}x^3$

62. $n(x) = \frac{1}{3}|x-2|$

63. $p(x) = \left(\frac{1}{3}x\right)^2 - 3$

64. $q(x) = \left(\frac{1}{4}x\right)^3 + 1$

65. $a(x) = \sqrt{-x+4}$

66. $b(x) = \sqrt[3]{-x-6}$

Determine the interval(s) on which the function is increasing and decreasing

67. $f(x) = 4(x+1)^2 - 5$

68. $g(x) = 5(x+3)^2 - 2$

69. $a(x) = \sqrt{-x+4}$

70. $k(x) = -3\sqrt{x} - 1$

Determine the interval(s) on which the function is concave up and concave down

71. $m(x) = -2(x+3)^3 + 1$

72. $b(x) = \sqrt[3]{-x-6}$

73. $p(x) = \left(\frac{1}{3}x\right)^2 - 3$

74. $k(x) = -3\sqrt{x} - 1$

The function $f(x)$ is graphed here. Write an equation for each graph below as a transformation of $f(x)$.

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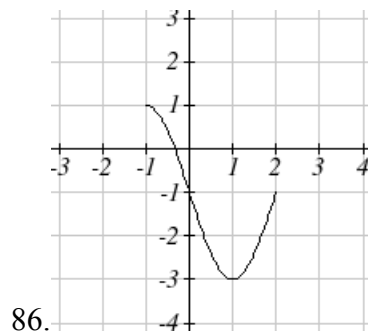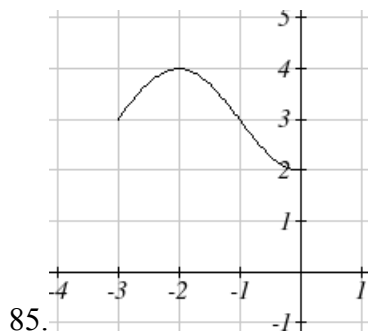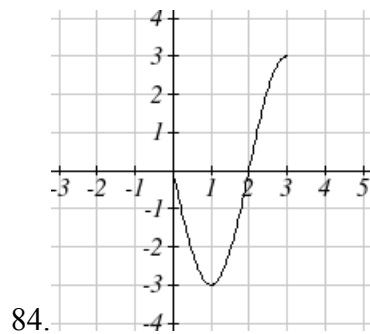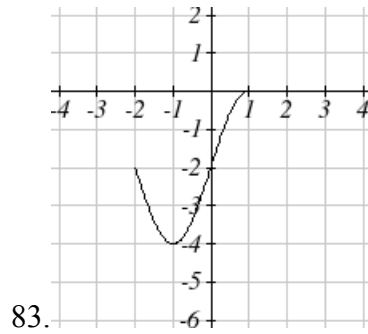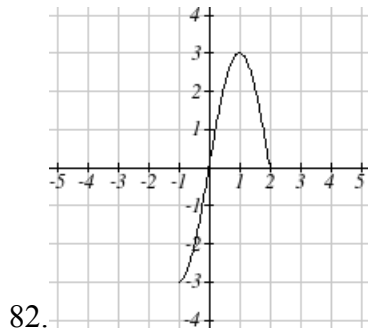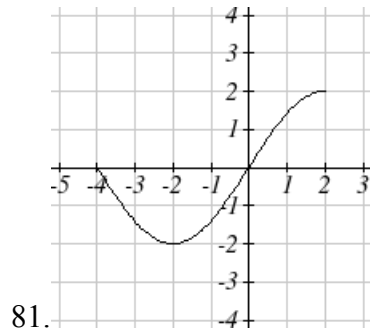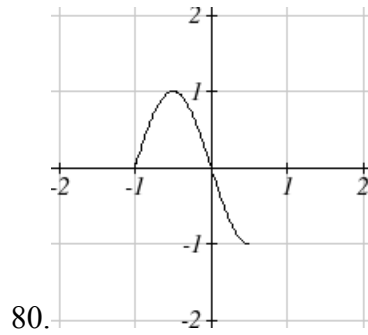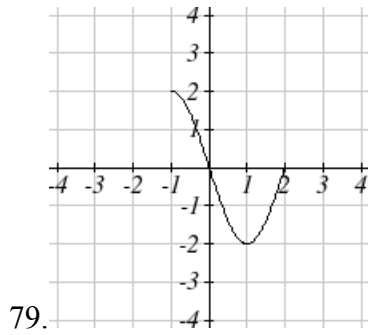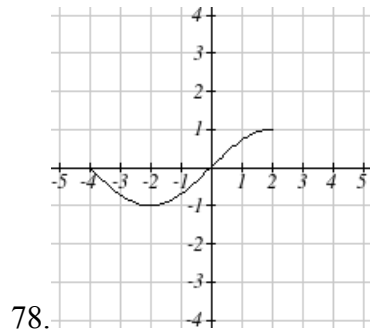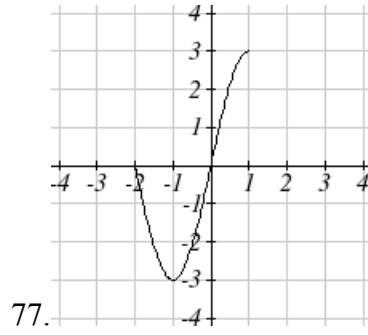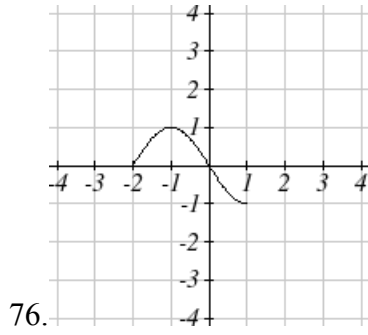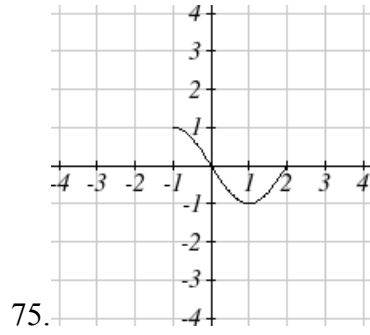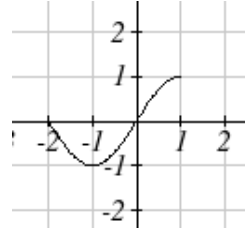
Write an equation for the transformed toolkit function graphed below.

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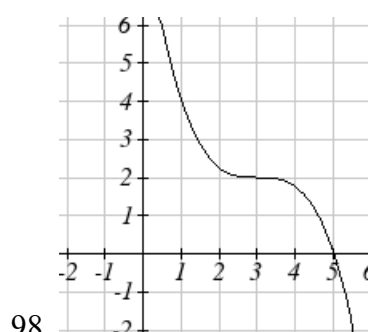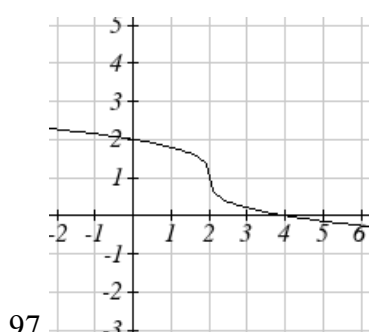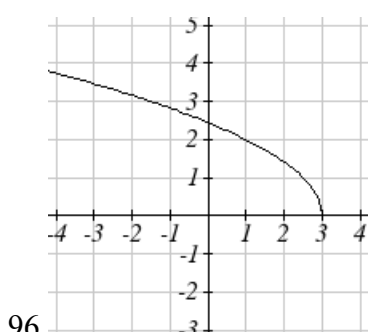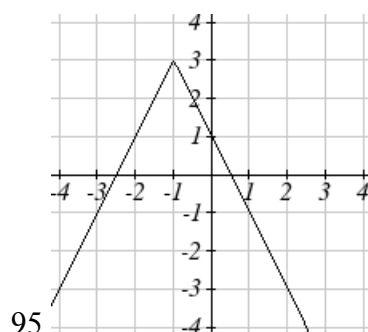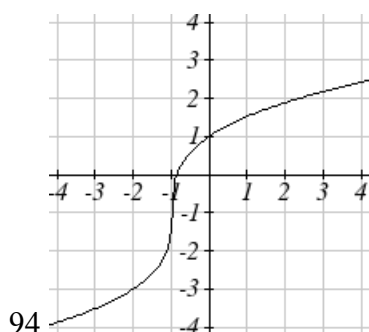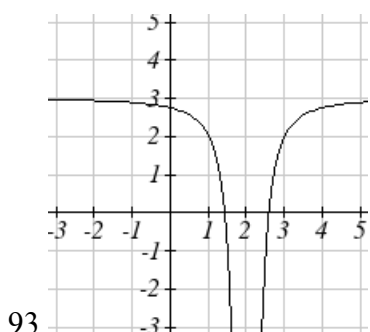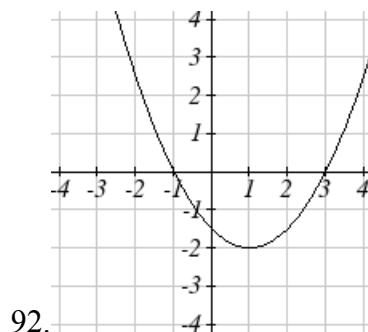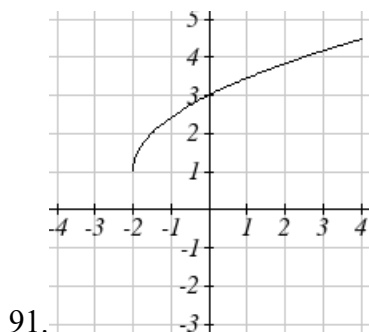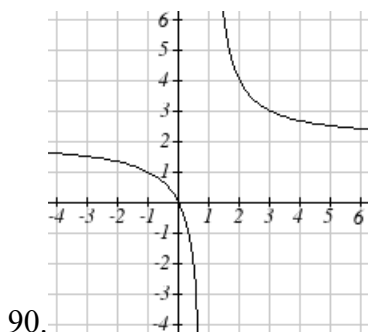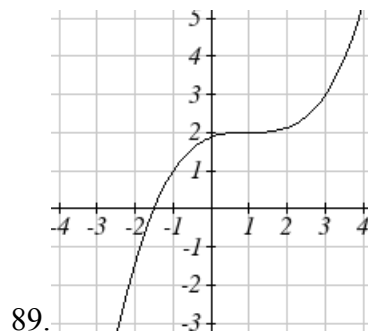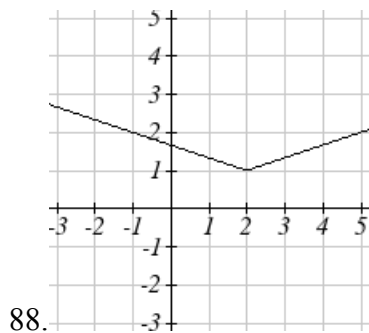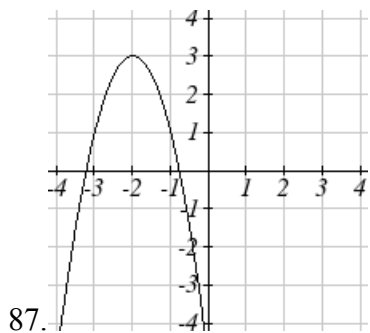
99. Suppose you have a function $y = f(x)$ such that the domain of $f(x)$ is $1 \leq x \leq 6$ and the range of $f(x)$ is $-3 \leq y \leq 5$. [UW]

   a. What is the domain of $f(2(x-3))$?

   b. What is the range of $f(2(x-3))$?

   c. What is the domain of $2f(x)-3$?

   d. What is the range of $2f(x)-3$?

   e. Can you find constants B and C so that the domain of $f(B(x-C))$ is $8 \leq x \leq 9$?

   f. Can you find constants A and D so that the range of $Af(x)+D$ is $0 \leq y \leq 1$?

Section 1.6 Exercises

Assume that the function f is a one-to-one function.

1. If $f(6) = 7$, find $f^{-1}(7)$

2. If $f(3) = 2$, find $f^{-1}(2)$

3. If $f^{-1}(-4) = -8$, find $f(-8)$

4. If $f^{-1}(-2) = -1$, find $f(-1)$

5. If $f(5) = 2$, find $\left(f(5)\right)^{-1}$

6. If $f(1) = 4$, find $\left(f(1)\right)^{-1}$

7. Using the graph of $f(x)$ shown
   a. Find $f(0)$
   b. Solve $f(x) = 0$
   c. Find $f^{-1}(0)$
   d. Solve $f^{-1}(x) = 0$
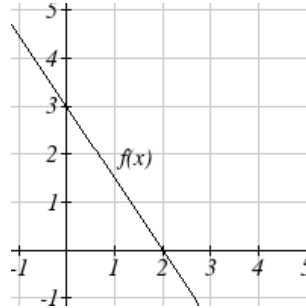
8. Using the graph shown
   a. Find $g(1)$
   b. Solve $g(x) = 1$
   c. Find $g^{-1}(1)$
   d. Solve $g^{-1}(x) = 1$
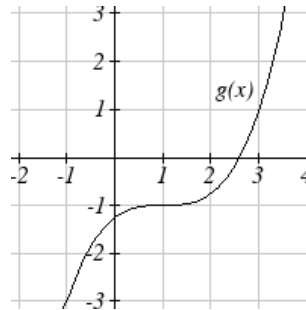
9. Use the table below to fill in the missing values.

x	0	1	2	3	4	5	6	7	8	9
f(x)	8	0	7	4	2	6	5	3	9	1

   a. Find $f(1)$
   b. Solve $f(x) = 3$
   c. Find $f^{-1}(0)$
   d. Solve $f^{-1}(x) = 7$

10. Use the table below to fill in the missing values.

t	0	1	2	3	4	5	6	7	8
h(t)	6	0	1	7	2	3	5	4	9

     a. Find $h(6)$

     b. Solve $h(t) = 0$

     c. Find $h^{-1}(5)$

     d. Solve $h^{-1}(t) = 1$

For each table below, create a table for $f^{-1}(x)$.

11.

x	3	6	9	13	14
f(x)	1	4	7	12	16

12.

x	3	5	7	13	15
f(x)	2	6	9	11	16

For each function below, find $f^{-1}(x)$

13. $f(x) = x + 3$

14. $f(x) = x + 5$

15. $f(x) = 2 - x$

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

17. $f(x) = 11x + 7$

18. $f(x) = 9 + 10x$

For each function, find a domain on which f is one-to-one and non-decreasing, then find the inverse of f restricted to that domain.

19. $f(x) = (x+7)^2$

20. $f(x) = (x-6)^2$

21. $f(x) = x^2 - 5$

22. $f(x) = x^2 + 1$

23. If $f(x) = x^3 - 5$ and $g(x) = \sqrt[3]{x+5}$, find

     a. $f(g(x))$

     b. $g(f(x))$

     c. What does this tell us about the relationship between $f(x)$ and $g(x)$?

24. If $f(x) = \dfrac{x}{2+x}$ and $g(x) = \dfrac{2x}{1-x}$, find

     a. $f(g(x))$

     b. $g(f(x))$

     c. What does this tell us about the relationship between $f(x)$ and $g(x)$?

Section 2.1 Exercises

1. A town's population has been growing linearly. In 2003, the population was 45,000, and the population has been growing by 1700 people each year. Write an equation $P(t)$, for the population t years after 2003.

2. A town's population has been growing linearly. In 2005, the population was 69,000, and the population has been growing by 2500 people each year. Write an equation $P(t)$, for the population t years after 2005.

3. Sonya is currently 10 miles from home, and is walking further away at 2 miles per hour. Write an equation for her distance from home t hours from now.

4. A boat is 100 miles away from the marina, sailing directly towards it at 10 miles per hour. Write an equation for the distance of the boat from the marina after t hours.

5. Timmy goes to the fair with $40. Each ride costs $2. How much money will he have left after riding n rides?

6. At noon, a barista notices she has $20 in her tip jar. If she makes an average of $0.50 from each customer, how much will she have in her tip jar if she serves n more customers during her shift?

Determine if each function is increasing or decreasing

7. $f(x) = 4x + 3$

8. $g(x) = 5x + 6$

9. $a(x) = 5 - 2x$

10. $b(x) = 8 - 3x$

11. $h(x) = -2x + 4$

12. $k(x) = -4x + 1$

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

14. $p(x) = \frac{1}{4}x - 5$

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

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

Find the slope of the line that passes through the two given points

17. (2, 4) and (4, 10)

18. (1, 5) and (4, 11)

19. (-1,4) and (5, 2)

20. (-2, 8) and (4, 6)

21. (6,11) and (-4,3)

22. (9,10) and (-6,-12)

Find the slope of the lines graphed

23.

24.
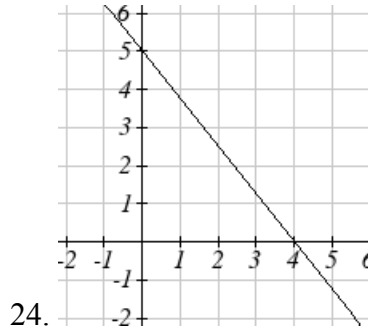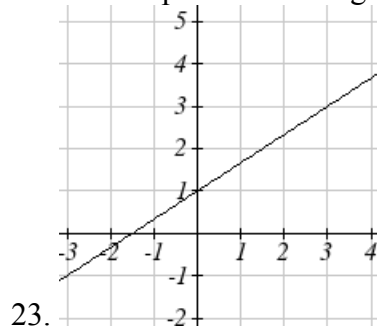
25. Sonya is walking home from a friend's house. After 2 minutes she is 1.4 miles from home. Twelve minutes after leaving, she is 0.9 miles from home. What is her rate?

26. A gym membership with two personal training sessions costs $125, while gym membership with 5 personal training sessions costs $260. What is the rate for personal training sessions?

27. A city's population in the year 1960 was 287,500. In 1989 the population was 275,900. Compute the slope of the population growth (or decline) and make a statement about the population rate of change in people per year.

28. A city's population in the year 1958 was 2,113,000. In 1991 the population was 2,099,800. Compute the slope of the population growth (or decline) and make a statement about the population rate of change in people per year.

29. A phone company charges for service according to the formula: $C(n) = 24 + 0.1n$, where n is the number of minutes talked, and $C(n)$ is the monthly charge, in dollars. Find and interpret the rate of change and initial value.

30. A phone company charges for service according to the formula: $C(n) = 26 + 0.04n$, where n is the number of minutes talked, and $C(n)$ is the monthly charge, in dollars. Find and interpret the rate of change and initial value.

31. Terry is skiing down a steep hill. Terry's elevation, $E(t)$, in feet after t seconds is given by $E(t) = 3000 - 70t$. Write a complete sentence describing Terry's starting point and how it is changing over time.

32. Maria is climbing a mountain. Maria's elevation, $E(t)$, in feet after t minutes is given by $E(t)1200+40t$. Write a complete sentence describing Maria's starting point and how it is changing over time.

Given each set of information, find a linear equation satisfying the conditions, if possible

33. $f(-5)=-4$, and $f(5)=2$
34. $f(-1)=4$, and $f(5)=1$

35. Passes through (2, 4) and (4, 10)
36. Passes through (1, 5) and (4, 11)

37. Passes through (-1,4) and (5, 2)
38. Passes through (-2, 8) and (4, 6)

39. x intercept at (-2, 0) and y intercept at (0, -3)

40. x intercept at (-5, 0) and y intercept at (0, 4)

Find an equation for the function graphed

41.

42.

43.

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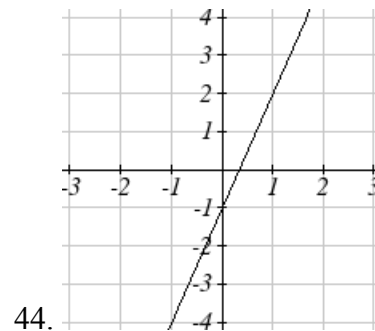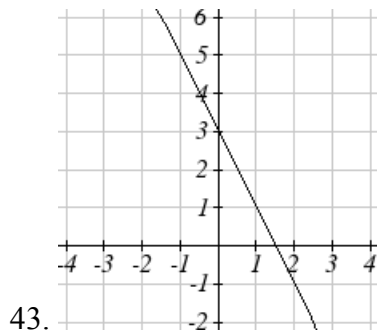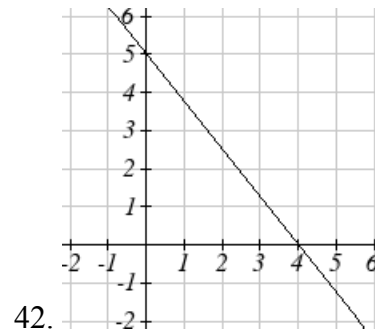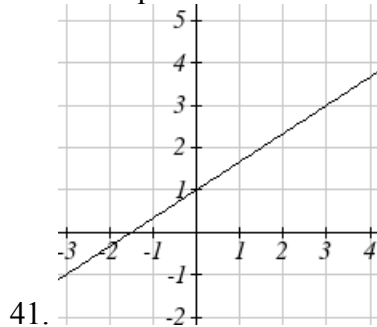
45. A clothing business finds there is a linear relationship between the number of shirts, n, it can sell and the price, p, it can charge per shirt. In particular, historical data shows that 1000 shirts can be sold at a price of $30, while 3000 shirts can be sold at a price of $22. Find a linear equation in the form $p = mn + b$ that gives the price p they can charge for n shirts.

46. A farmer finds there is a linear relationship between the number of bean stalks, n, she plants and the yield, y, each plant produces. When she plants 30 stalks, each plant yields 30 oz of beans. When she plants 34 stalks, each plant produces 28 oz of beans. Find a linear relationships in the form $y = mn + b$ that gives the yield when n stalks are planted.

47. Which of the following tables which could represent a linear function? For each that could be linear, find a linear equation models the data.

x	g(x)
0	5
5	-10
10	-25
15	-40

x	h(x)
0	5
5	30
10	105
15	230

x	f(x)
0	-5
5	20
10	45
15	70

x	k(x)
5	13
10	28
20	58
25	73

48. Which of the following tables which could represent a linear function? For each that could be linear, find a linear equation models the data.

x	g(x)
0	6
2	-19
4	-44
6	-69

x	h(x)
2	13
4	23
8	43
10	53

x	f(x)
2	-4
4	16
6	36
8	56

x	k(x)
0	6
2	31
6	106
8	231

49. While speaking on the phone to a friend in Oslo, Norway, you learned that the current temperature there was -23 Celsius (-23°C). After the phone conversation, you wanted to convert this temperature to Fahrenheit degrees °F, but you could not find a reference with the correct formulas. You then remembered that the relationship between °F and °C is linear. [UW]
    a. Using this and the knowledge that 32°F = 0 °C and 212 °F = 100 °C, find an equation that computes Celsius temperature in terms of Fahrenheit; i.e. an equation of the form C = "an expression involving only the variable F."
    b. Likewise, find an equation that computes Fahrenheit temperature in terms of Celsius temperature; i.e. an equation of the form F = "an expression involving only the variable C."
    c. How cold was it in Oslo in °F?

Section 2.2 Exercises

Match each linear equation with its graph

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

2. $f(x) = -2x - 1$

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

4. $f(x) = 2$

5. $f(x) = 2 + x$

6. $f(x) = 3x + 2$
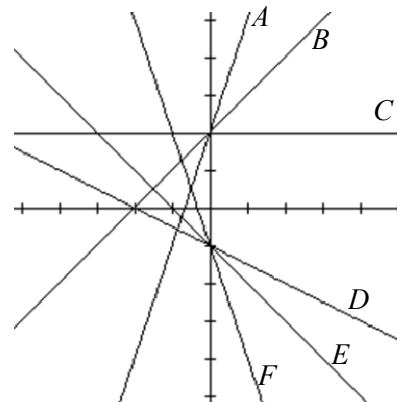
Sketch a line with the given features
7. An *x*-intercept of (-4, 0) and *y*-intercept of (0, -2)

8. An *x*-intercept of (-2, 0) and *y*-intercept of (0, 4)

9. A vertical intercept of (0, 7) and slope $-\dfrac{3}{2}$

10. A vertical intercept of (0, 3) and slope $\dfrac{2}{5}$

11. Passing through the points (-6,-2) and (6,-6)

12. Passing through the points (-3,-4) and (3,0)

Sketch each equation
13. $f(x) = -2x - 1$ 14. $g(x) = -3x + 2$

15. $h(x) = \dfrac{1}{3}x + 2$ 16. $k(x) = \dfrac{2}{3}x - 3$

17. $k(t) = 3 + 2t$ 18. $p(t) = -2 + 3t$

19. $x = 3$ 20. $x = -2$

21. $r(x) = 4$ 22. $q(x) = 3$

23. If $g(x)$ is the $f(x) = x$ after a vertical compression by $3/4$, a shift left by 2, and a shift down by 4
    a. Write an equation for $g(x)$
    b. What is the slope of this line?
    c. Find the vertical intercept of this line.

24. If $g(x)$ is the $f(x) = x$ after a vertical compression by $1/3$, a shift right by 1, and a shift up by 3
    a. Write an equation for $g(x)$
    b. What is the slope of this line?
    c. Find the vertical intercept of this line.

Write the equation of the line shown
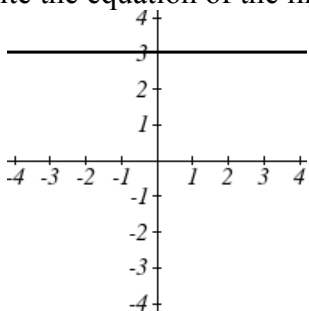
25.
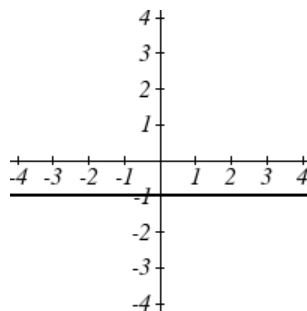
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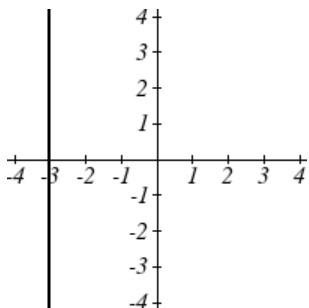
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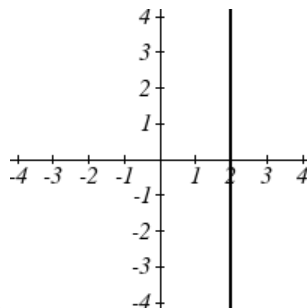
28.

Find the horizontal and vertical intercepts of each equation

29. $f(x) = -x + 2$ 30. $g(x) = 2x + 4$

31. $h(x) = 3x - 5$ 32. $k(x) = -5x + 1$

33. $-2x + 5y = 20$ 34. $7x + 2y = 56$

Given below are descriptions of two lines. Find the slope of Line 1 and Line 2. Are each pair of lines parallel, perpendicular or neither?

35. Line 1: Passes through $(0,6)$ and $(3,-24)$

Line 2: Passes through $(-1,19)$ and $(8,-71)$

36. Line 1: Passes through $(-8,-55)$ and $(10,89)$

Line 2: Passes through $(9,-44)$ and $(4,-14)$

37. Line 1: Passes through $(2,3)$ and $(4,-1)$

Line 2: Passes through $(6,3)$ and $(8,5)$

38. Line 1: Passes through $(1,7)$ and $(5,5)$

Line 2: Passes through $(-1,-3)$ and $(1,1)$

39. Line 1: Passes through $(0,5)$ and $(3,3)$

Line 2: Passes through $(1,-5)$ and $(3,-2)$

40. Line 1: Passes through $(2,5)$ and $(5,-1)$

Line 2: Passes through $(-3,7)$ and $(3,-5)$

41. Write an equation for a line parallel to $f(x) = -5x - 3$ and passing through the point (2,-12)

42. Write an equation for a line parallel to $g(x) = 3x - 1$ and passing through the point (4,9)

43. Write an equation for a line perpendicular to $h(t) = -2t + 4$ and passing through the point (-4,-1)

44. Write an equation for a line perpendicular to $p(t) = 3t + 4$ and passing through the point (3,1)

45. Find the point at which the line $f(x) = -2x - 1$ intersects the line $g(x) = -x$

46. Find the point at which the line $f(x) = 2x + 5$ intersects the line $g(x) = -3x - 5$

47. Use algebra to find the point at which the line $f(x) = -\dfrac{4}{5}x + \dfrac{274}{25}$ intersects the line

$h(x) = \dfrac{9}{4}x + \dfrac{73}{10}$

48. Use algebra to find the point at which the line $f(x) = \dfrac{7}{4}x + \dfrac{457}{60}$ intersects the line

$g(x) = \dfrac{4}{3}x + \dfrac{31}{5}$

49. A car rental company offers two plans for renting a car.
    Plan A: 30 dollars per day and 18 cents per mile
    Plan B: 50 dollars per day with free unlimited mileage
    For what range of miles will plan B save you money?

50. A cell phone company offers two data options for its prepaid phones
    Pay per use: $0.002 per Kilobyte (KB) used
    Data Package: $5 for 5 Megabytes (5120 Kilobytes) + $0.002 per addition KB
    Assuming you will use less than 5 Megabytes, for what range of use will the data package save you money?

51. Sketch an accurate picture of the line having equation $f(x) = 2 - \dfrac{1}{2}x$. Let c be an unknown constant. [UW]
    a. Find the point of intersection between the line you have graphed and the line $g(x) = 1 + cx$; your answer will be a point in the xy plane whose coordinates involve the unknown c.
    b. Find c so that the intersection point in (a) has x-coordinate 10.
    c. Find c so that the intersection point in (a) lies on the x-axis.

Section 2.3 Exercises

1. In 2004, a school population was 1001. By 2008 the population had grown to 1697.
    a. How much did the population grow between the year 2004 and 2008?
    b. How long did it take the population to grow from 1001 students to 1697 students?
    c. What is the average population growth per year?
    d. What was the population in the year 2000?
    e. Find an equation for the population, P, of the school t years after 2000.
    f. Using your equation, predict the population of the school in 2011.

2. In 2003, a town's population was 1431. By 2007 the population had grown to 2134.
    a. How much did the population grow between the year 2003 and 2007?
    b. How long did it take the population to grow from 1431 people to 2134?
    c. What is the average population growth per year?
    d. What was the population in the year 2000?
    e. Find an equation for the population, P, of the town t years after 2000.
    f. Using your equation, predict the population of the town in 2014.

3. A phone company has a monthly cellular plan where a customer pays a flat monthly fee and then a certain amount of money per minute used on the phone. If a customer uses 410 minutes, the monthly cost will be $71.50. If the customer uses 720 minutes, the monthly cost will be $118.
    a. Find a linear equation for the monthly cost of the cell plan as a function of x, the number of monthly minutes used.
    b. Interpret the slope and vertical intercept of the equation.
    c. Use your equation to find the total monthly cost if 687 minutes are used.

4. A phone company has a monthly cellular data plan where a customer pays a flat monthly fee and then a certain amount of money per megabyte (MB) of data used on the phone. If a customer uses 20 MB, the monthly cost will be $11.20. If the customer uses 130 MB, the monthly cost will be $17.80.
    a. Find a linear equation for the monthly cost of the data plan as a function of x, the number of MB used.
    b. Interpret the slope and vertical intercept of the equation.
    c. Use your equation to find the total monthly cost if 250 MB are used.

5. In 1991, the moose population in a park was measured to be 4360. By 1999, the population was measured again to be 5880. If the population continues to change linearly,
    a. Find a formula for the moose population, P.
    b. What does your model predict the moose population to be in 2003?

6. In 2003, the owl population in a park was measured to be 340. By 2007, the population was measured again to be 285. If the population continues to change linearly,
    a. Find a formula for the owl population, P.
    b. What does your model predict the owl population to be in 2012?

7. The Federal Helium Reserve held about 16 billion cubic feet of helium in 2010, and is being depleted by about 2.1 billion cubic feet each year.
    a. Give a linear equation for the remaining federal helium reserves, R, in terms of t, the number of years since 2010.
    b. In 2015, what will the helium reserves be?
    c. If the rate of depletion isn't change, when will the Federal Helium Reserve be depleted?

8. Suppose the world's current oil reserves are 1820 billion barrels. If, on average, the total reserves is decreasing by 25 billion barrels of oil each year:
    a. Give a linear equation for the remaining oil reserves, R, in terms of t, the number of years since now.
    b. Seven years from now, what will the oil reserves be?
    c. If the rate of depletion isn't change, when will the world's oil reserves be depleted?

9. You are choosing between two different prepaid cell phone plans. The first plan charges a rate of 26 cents per minute. The second plan charges a monthly fee of $19.95 *plus* 11 cents per minute. How many minutes would you have to use in a month in order for the second plan to be preferable?

10. You are choosing between two different window washing companies. The first charges $5 per window. The second charges a base fee of $40 plus $3 per window. How many windows would you need to have for the second company to be preferable?

11. When hired at a new job selling jewelry, you are given two pay options:
    Option A: Base salary of $17,000 a year, with a commission of 12% of your sales
    Option B: Base salary of $20,000 a year, with a commission of 5% of your sales
    How much jewelry would you need to sell for option A to produce a larger income?

12. When hired at a new job selling electronics, you are given two pay options:
    Option A: Base salary of $14,000 a year, with a commission of 10% of your sales
    Option B: Base salary of $19,000 a year, with a commission of 4% of your sales
    How much electronics would you need to sell for option A to produce a larger income?

13. Find the area of a triangle bounded by the y axis, the line $f(x) = 9 - \dfrac{6}{7}x$, and the line perpendicular to $f(x)$ that passes through the origin.

14. Find the area of a triangle bounded by the x axis, the line $f(x) = 12 - \dfrac{1}{3}x$, and the line perpendicular to $f(x)$ that passes through the origin.

15. Find the area of a parallelogram bounded by the y axis, the line $x = 3$, the line $f(x) = 1 + 2x$, and the line parallel to $f(x)$ passing through (2, 7)

16. Find the area of a parallelogram bounded by the x axis, the line $g(x) = 2$, the line $f(x) = 3x$, and the line parallel to $f(x)$ passing through (6, 1)

17. If $b > 0$ and $m < 0$, then the line $f(x) = b + mx$ cuts off a triangle from the first quadrant. Express the area of that triangle in terms of m and b. [UW]

18. Find the value of m so the lines $f(x) = mx + 5$ and $g(x) = x$ and the y-axis form a triangle with an area of 10. [UW]

19. The median home value in Mississippi and Hawaii (adjusted for inflation) are shown below. If we assume that the house values are changing linearly,

Year	Mississippi	Hawaii
1950	25200	74400
2000	71400	272700

    a. In which state have home values increased at a higher rate?
    b. If these trends were to continue, what would be the median home value in Mississippi in 2010?
    c. If we assume the linear trend existed before 1950 and continues after 2000, the two states' median house values will be (or were) equal in what year? (The answer might be absurd)

20. The median home value in Indiana and Alabama (adjusted for inflation) are shown
    below. If we assume that the house values are changing linearly,

Year	Indiana	Alabama
1950	37700	27100
2000	94300	85100

   a. In which state have home values increased at a higher rate?
   b. If these trends were to continue, what would be the median home value in
       Indiana in 2010?
   c.   If we assume the linear trend existed before 1950 and continues after 2000,
       the two states' median house values will be (or were) equal in what year? (The
       answer might be absurd)

21. Pam is taking a train from the town of Rome to the town of Florence. Rome is located
    30 miles due West of the town of Paris. Florence is 25 miles East, and 45 miles North
    of Rome. On her trip, how close does Pam get to Paris? [UW]

22. You're flying from Joint Base Lewis-McChord (JBLM) to an undisclosed location
    226 km south and 230 km east. Mt. Rainier is located approximately 56 km east and
    40 km south of JBLM. If you are flying at a constant speed of 800 km/hr, how long
    after you depart JBLM will you be the closest to Mt. Rainier?

Section 2.4 Exercises

1. The following is data for the first and second Quiz scores for 8 students in a class. Plot the points, then sketch a line that best fits the data.

First Quiz	11	20	24	25	33	42	46	49
Second Quiz	10	16	23	28	30	39	40	49

2. Eight students were asked to estimate their score on a 10 point quiz.   Their estimated and actual scores are given. Plot the points, then sketch a line that best fits the data.

Predicted	5	7	6	8	10	9	10	7
Actual	6	6	7	8	9	9	10	6

Based on each set of data given, calculate the regression line using your calculator or other technology tool, and determine the correlation coefficient.

3.

x	y
5	4
7	12
10	17
12	22
15	24

4.

x	y
8	23
15	41
26	53
31	72
56	103

5.

x	y
3	21.9
4	22.22
5	22.74
6	22.26
7	20.78
8	17.6
9	16.52
10	18.54
11	15.76
12	13.68
13	14.1
14	14.02
15	11.94
16	12.76
17	11.28
18	9.1

6.

x	y
4	44.8
5	43.1
6	38.8
7	39
8	38
9	32.7
10	30.1
11	29.3
12	27
13	25.8
14	24.7
15	22
16	20.1
17	19.8
18	16.8

7. A regression was run to determine if there is a relationship between hours of TV watched per day (x) and number of situps a person can do (y). The results of the regression are given below. Use this to predict the number of situps a person who watches 11 hours of TV can do.

```
y=ax+b
a=-1.341
b=32.234
r²=0.803
r=-0.896
```

8. A regression was run to determine if there is a relationship between the diameter of a tree (x, in inches) and the tree's age (y, in years). The results of the regression are given below. Use this to predict the age of a tree with diameter 10 inches.
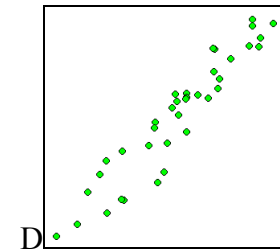
```
y=ax+b
a=6.301
b=-1.044
r²=0.940
r=-0.970
```
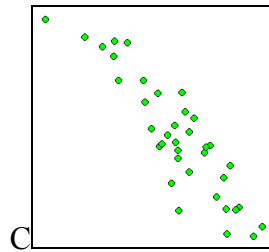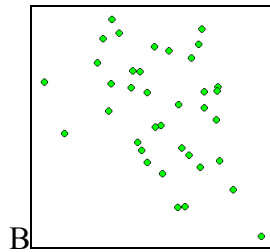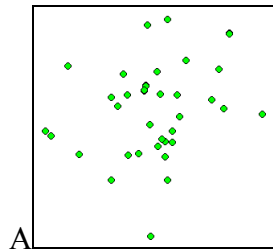
Match each scatterplot shown below with one of the four specified correlations.

9. $r = 0.95$ 10. $r = -0.89$ 11. $r = 0.26$ 12. $r = -0.39$

13. The US census tracks the percentage of persons 25 years or older who are college graduates. That data for several years is given below. Determine if the trend appears linear. If so and the trend continues, in what year will the percentage exceed 35%?

Year	1990	1992	1994	1996	1998	2000	2002	2004	2006	2008
Percent Graduates	21.3	21.4	22.2	23.6	24.4	25.6	26.7	27.7	28	29.4

14. The US import of wine (in hectoliters) for several years if given below. Determine if the trend appears linear. If so and the trend continues, in what year will imports exceed 12,000 hectoliters?
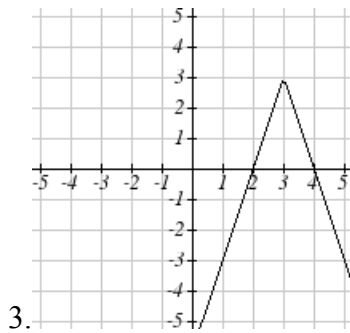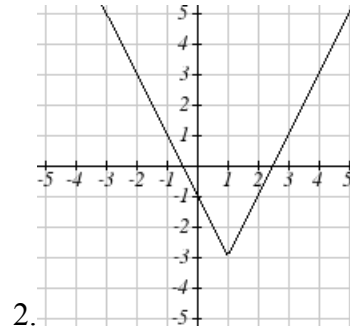
Year	1992	1994	1996	1998	2000	2002	2004	2006	2008	2009
Imports	2665	2688	3565	4129	4584	5655	6549	7950	8487	9462

Section 2.5 Exercises

Write an equation for each transformation of $f(x) = |x|$

1.

2.

3.

4.
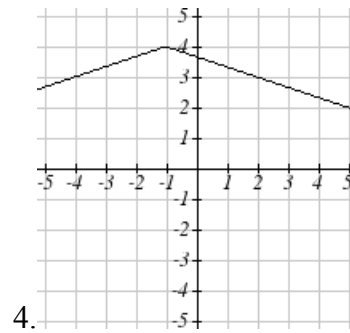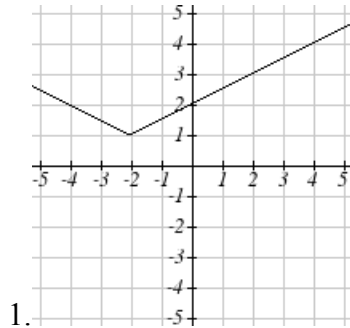
Sketch a graph of each function

5. $f(x) = -|x-1| - 1$

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

7. $f(x) = 2|x+3| + 1$

8. $f(x) = 3|x-2| - 3$

9. $f(x) = |2x-4| - 3$

10. $f(x) = |3x+9| + 2$

Solve each the equation

11. $|5x-2| = 11$

12. $|4x+2| = 15$

13. $2|4-x| = 7$

14. $3|5-x| = 5$

15. $3|x+1| - 4 = -2$

16. $5|x-4| - 7 = 2$

Find the horizontal and vertical intercepts of each function

17. $f(x) = 2|x+1| - 10$

18. $f(x) = 4|x-3| + 4$

19. $f(x) = -3|x-2| - 1$

20. $f(x) = -2|x+1| + 6$

Solve each inequality

21. $|x+5| < 6$

22. $|x-3| < 7$

23. $|x-2| \geq 3$

24. $|x+4| \geq 2$

25. $|3x+9| < 4$

26. $|2x-9| \leq 8$

Section 3.1 Exercises

Find the long run behavior of each function as $x \to \infty$ and $x \to -\infty$

1. $f(x) = x^4$ 2. $f(x) = x^6$ 3. $f(x) = x^3$ 4. $f(x) = x^5$

5. $f(x) = -x^2$ 6. $f(x) = -x^4$ 7. $f(x) = -x^7$ 8. $f(x) = -x^9$

Find the degree and leading coefficient of each polynomial

9. $4x^7$ 10. $5x^6$

11. $5 - x^2$ 12. $6 + 3x - 4x^3$

13. $-2x^4 - 3x^2 + x - 1$ 14. $6x^5 - 2x^4 + x^2 + 3$

15. $(2x + 3)(x - 4)(3x + 1)$ 16. $(3x + 1)(x + 1)(4x + 3)$

Find the long run behavior of each function as $x \to \infty$ and $x \to -\infty$

17. $-2x^4 - 3x^2 + x - 1$ 18. $6x^5 - 2x^4 + x^2 + 3$

19. $3x^2 + x - 2$ 20. $-2x^3 + x^2 - x + 3$

21. What is the maximum number of x-intercepts and turning points for a polynomial of degree 5?

22. What is the maximum number of x-intercepts and turning points for a polynomial of degree 8?

What is the least possible degree of each graph?

23.   24.   25.   26.
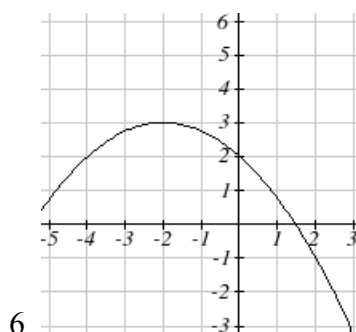

27.   28.   29.   30.
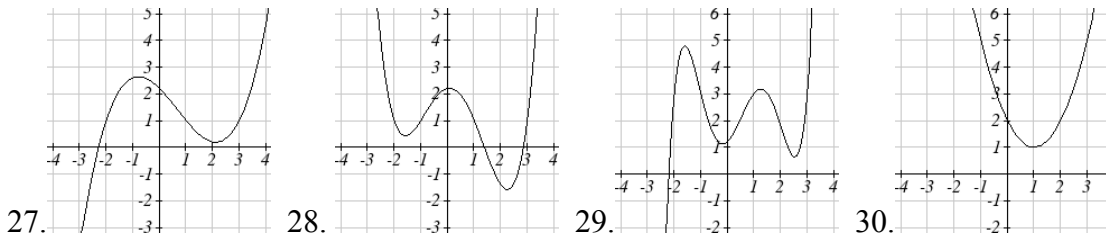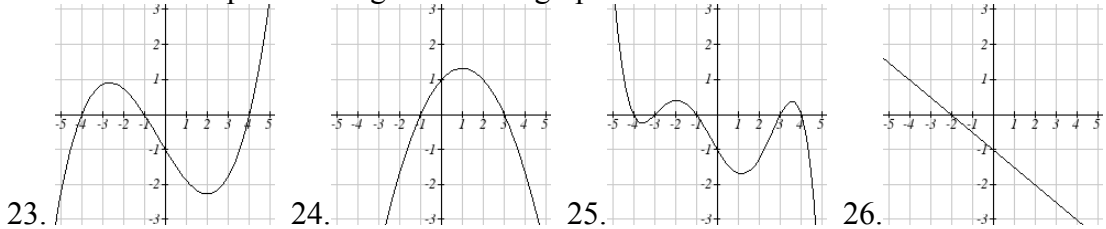
Find the vertical and horizontal intercepts of each function

31. $f(t) = 2(t - 1)(t + 2)(t - 3)$ 32. $f(x) = 3(x + 1)(x - 4)(x + 5)$

33. $g(n) = -2(3n - 1)(2n + 1)$ 34. $k(u) = -3(4 - n)(4n + 3)$

Section 3.2 Exercises

Write an equation for the quadratic graphed

1.

2.

3.

4.

5.

6.
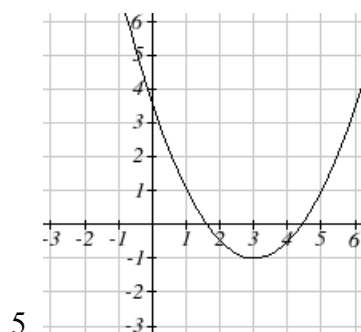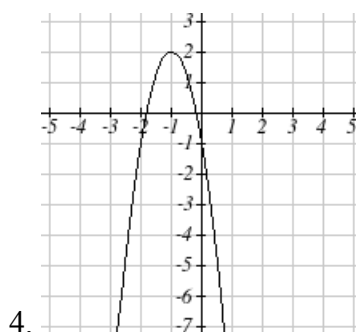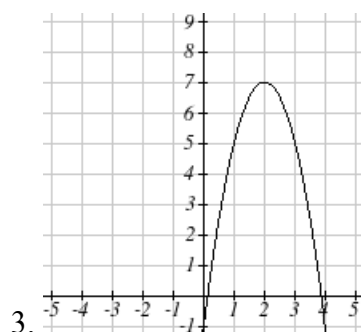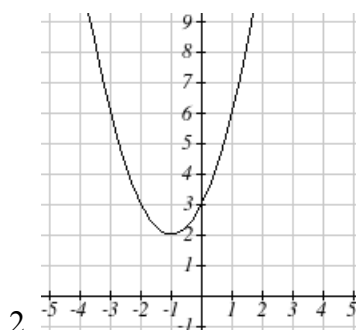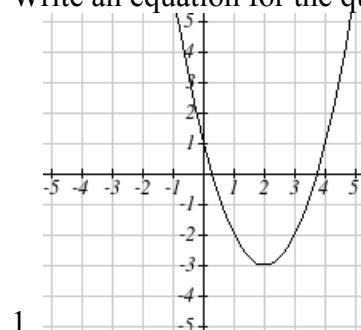
For each of the follow quadratics, find a) the vertex, b) the vertical intercept, and c) the horizontal intercepts.

7. $y(x) = 2x^2 + 10x + 12$

8. $z(p) = 3x^2 + 6x - 9$

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

10. $g(x) = -2x^2 - 14x + 12$

11. $h(t) = -4t^2 + 6t - 1$

12. $k(t) = 2x^2 + 4x - 15$

Rewrite the quadratic into vertex form

13. $f(x) = x^2 - 12x + 32$

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

15. $h(x) = 2x^2 + 8x - 10$

16. $k(x) = 3x^2 - 6x - 9$

17. Find the values of b and c so $f(x) = -8x^2 + bx + c$ has vertex $(2, -7)$

18. Find the values of b and c so $f(x) = 6x^2 + bx + c$ has vertex $(7, -9)$

Write an equation for a quadratic with the given features
19. x-intercepts (-3, 0) and (1, 0), and y intercept (0, 2)
20. x-intercepts (2, 0) and (-5, 0), and y intercept (0, 3)
21. x-intercepts (2, 0) and (5, 0), and y intercept (0, 6)
22. x-intercepts (1, 0) and (3, 0), and y intercept (0, 4)
23. Vertex at (4, 0), and y intercept (0, -4)
24. Vertex at (5, 6), and y intercept (0, -1)
25. Vertex at (-3, 2), and passing through (3, -2)
26. Vertex at (1, -3), and passing through (-2, 3)

27. A rocket is launched in the air. Its height, in meters above sea level, as a function of time is given by $h(t) = -4.9t^2 + 229t + 234$.

    a. From what height was the rocket launched?
    b. How high above sea level does the rocket get at its peak?
    c. Assuming the rocket will splash down in the ocean, at what time does splashdown occur?

28. A ball is thrown in the air from the top of a building. Its height, in meters above ground, as a function of time is given by $h(t) = -4.9t^2 + 24t + 8$.

    a. From what height was the ball thrown?
    b. How high above ground does the ball get at its peak?
    c. When does the ball hit the ground?

29. The height of a ball thrown in the air is given by $h(x) = -\dfrac{1}{12}x^2 + 6x + 3$, where x is the horizontal distance in feet from the point at which the ball is thrown.

    a. How high is the ball when it was thrown?
    b. What is the maximum height of the ball?
    c. How far from the thrower does the ball strike the ground?

30. A javelin is thrown in the air. Its height is given by $h(x) = -\dfrac{1}{20}x^2 + 8x + 6$, where x is the horizontal distance in feet from the point at which the javelin is thrown.

    a. How high is the javelin when it was thrown?
    b. What is the maximum height of the javelin?
    c. How far from the thrower does the javelin strike the ground?

31. A box with a square base and no top is to be made from a square piece of cardboard by cutting 6 in. squares from each corner and folding up the sides. The box is to hold 1000 in^3. How big a piece of cardboard is needed?

32. A box with a square base and no top is to be made from a square piece of cardboard by cutting 4 in. squares from each corner and folding up the sides. The box is to hold 2700 in^3. How big a piece of cardboard is needed?

33. A farmer wishes to enclose two pens with fencing, as shown. If the farmer has 500 feet of fencing to work with, what dimensions will maximize the area enclosed?
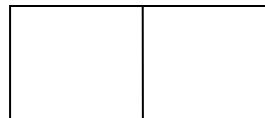
34. A farmer wishes to enclose three pens with fencing, as shown. If the farmer has 700 feet of fencing to work with, what dimensions will maximize the area enclosed?
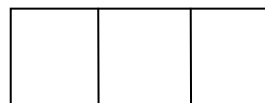
35. You have a wire that is 56 cm long. You wish to cut it into two pieces. One piece will be bent into the shape of a square. The other piece will be bent into the shape of a circle. Let A represent the total area of the square and the circle. What is the circumference of the circle when A is a minimum?

36. You have a wire that is 71 cm long. You wish to cut it into two pieces. One piece will be bent into the shape of a right triangle with base equal to height. The other piece will be bent into the shape of a circle. Let A represent the total area of the triangle and the circle. What is the circumference of the circle when A is a minimum?

37. A soccer stadium holds 62000 spectators. With a ticket price of $11 the average attendance has been 26,000. When the price dropped to $9, the average attendance rose to 31,000. Assuming that attendance is linearly related to ticket price, what ticket price would maximize revenue?

38. A farmer finds that if she plants 75 trees per acre, each tree will yield 20 bushels of fruit. She estimates that for each additional tree planted per acre, the yield of each tree will decrease by 3 bushels. How many trees should she plant per acre to maximize her harvest?

39. A hot air balloon takes off from the edge of a mountain lake. Impose a coordinate system as pictured and assume that the path of the balloon follows the graph of

$f(x) = -\dfrac{2}{2500}x^2 + 45x$. The land rises

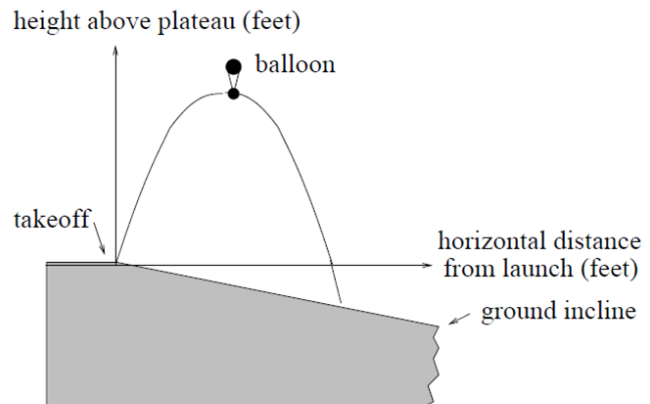at a constant incline from the lake at the rate of 2 vertical feet for each 20 horizontal feet. [UW]
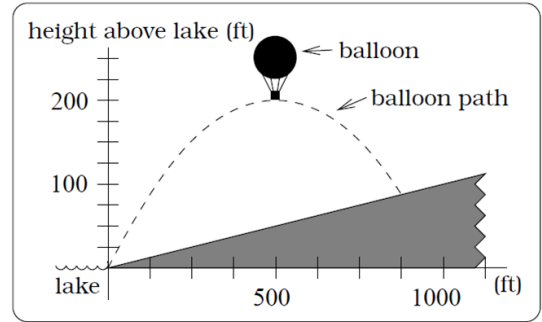
height above lake (ft)

← balloon

200

balloon path

100

lake

500   1000   (ft)

    a. What is the maximum height of the balloon above plateau level?
    b. What is the maximum height of the balloon above ground level?
    c. Where does the balloon land on the ground?
    d. Where is the balloon 50 feet above the ground?

40. A hot air balloon takes off from the edge of a plateau. Impose a coordinate system as pictured below and assume that the path the balloon follows is the graph of the quadratic function

$f(x) = -\dfrac{4}{2500}x^2 + \dfrac{4}{5}x$. The

land drops at a constant incline from the plateau at the rate of 1 vertical foot for each 5 horizontal feet. [UW]

height above plateau (feet)

balloon

takeoff

horizontal distance
from launch (feet)

ground incline

    a. What is the maximum height of the balloon above plateau level?
    b. What is the maximum height of the balloon above ground level?
    c. Where does the balloon land on the ground?
    d. Where is the balloon 50 feet above the ground?

Section 3.3 Exercises

Find the C and t intercepts of each function

1. $C(t) = 2(t-4)(t+1)(t-6)$

2. $C(t) = 3(t+2)(t-3)(t+5)$

3. $C(t) = 4t(t-2)^2(t+1)$

4. $C(t) = 2t(t-3)(t+1)^2$

5. $C(t) = 2t^4 - 8t^3 + 6t^2$

6. $C(t) = 4t^4 + 12t^3 - 40t^2$

Use your calculator or other graphing technology to solve graphically for the zeros of the function

7. $f(x) = x^3 - 7x^2 + 4x + 30$

8. $g(x) = x^3 - 6x^2 + x + 28$

Find the long run behavior of each function as $t \to \infty$ and $t \to -\infty$

9. $h(t) = 3(t-5)^3(t-3)^3(t-2)$

10. $k(t) = 2(t-3)^2(t+1)^3(t+2)$

11. $p(t) = -2t(t-1)(3-t)^2$

12. $q(t) = -4t(2-t)(t+1)^3$

Sketch a graph of each equation

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

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

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

16. $k(x) = (x-3)^3(x-2)^2$

17. $m(x) = -2x(x-1)(x+3)$

18. $n(x) = -3x(x+2)(x-4)$

Solve each inequality

19. $(x-3)(x-2)^2 > 0$

20. $(x-5)(x+1)^2 > 0$

21. $(x-1)(x+2)(x-3) < 0$

22. $(x-4)(x+3)(x+6) < 0$

Find the domain of each function

23. $f(x) = \sqrt{-42 + 19x - 2x^2}$

24. $g(x) = \sqrt{28 - 17x - 3x^2}$

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

26. $k(x) = \sqrt{2 + 7x + 3x^2}$

27. $n(x) = \sqrt{(x-3)(x+2)^2}$

28. $m(x) = \sqrt{(x-1)^2(x+3)}$

29. $p(t) = \dfrac{1}{t^2 + 2t - 8}$

30. $q(t) = \dfrac{4}{x^2 - 4x - 5}$

Write an equation for a polynomial the given features

31. Degree 3. Zeros at $x = -2$, $x = 1$, and $x = 3$. Vertical intercept at $(0, -4)$

32. Degree 3. Zeros at $x = -5$, $x = -2$, and $x = 1$. Vertical intercept at $(0, 6)$

33. Degree 5. Roots of multiplicity 2 at $x = 3$ and $x = 1$, and a root of multiplicity 1 at $x = -3$. Vertical intercept at $(0, 9)$

34. Degree 4. Root of multiplicity 2 at $x = 4$, and a roots of multiplicity 1 at $x = 1$ and $x = -2$. Vertical intercept at $(0, -3)$

35. Degree 5. Double zero at $x = 1$, and triple zero at $x = 3$. Passes through the point $(2, 15)$

36. Degree 5. Single zero at $x = -2$ and $x = 3$, and triple zero at $x = 1$. Passes through the point $(2, 4)$

Write an equation for the polynomial graphed

37.

38.

39.

40.

41.

42.

43.

44.

Write an equation for the polynomial graphed

45.

46.

47.

48.

49.

50.
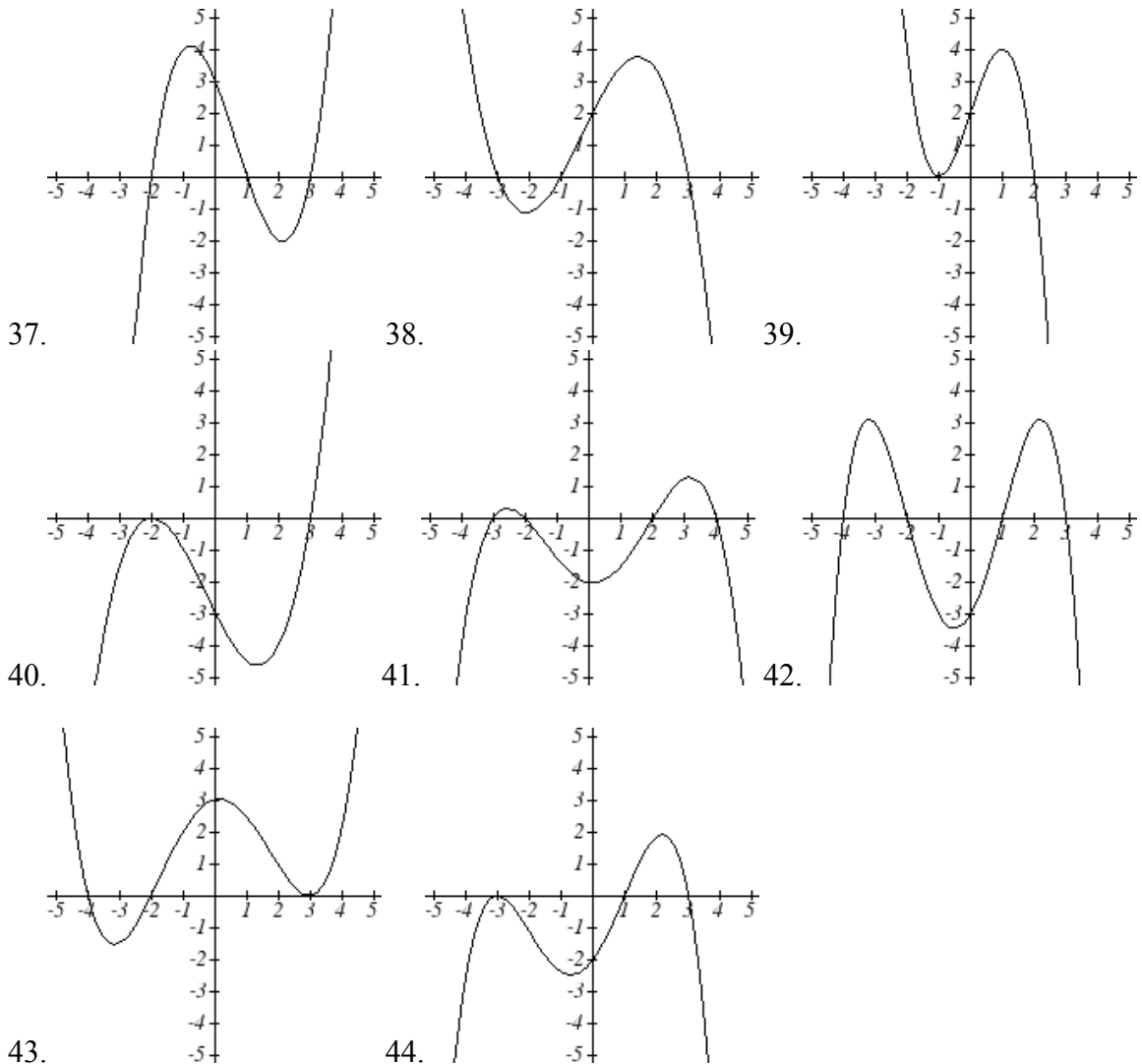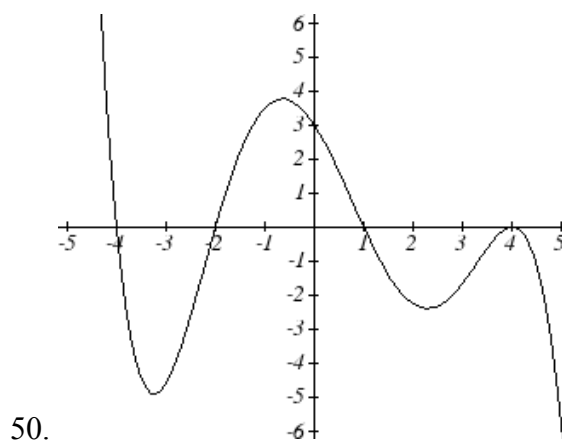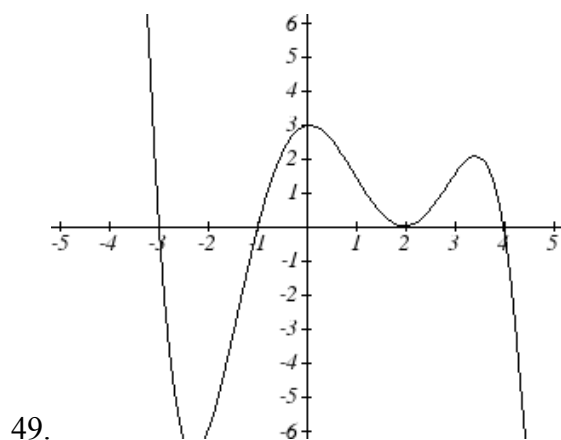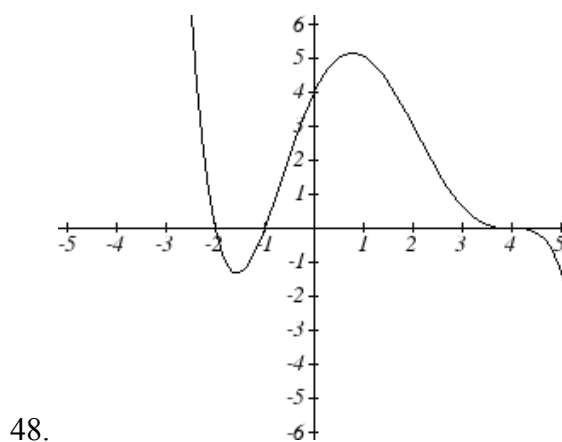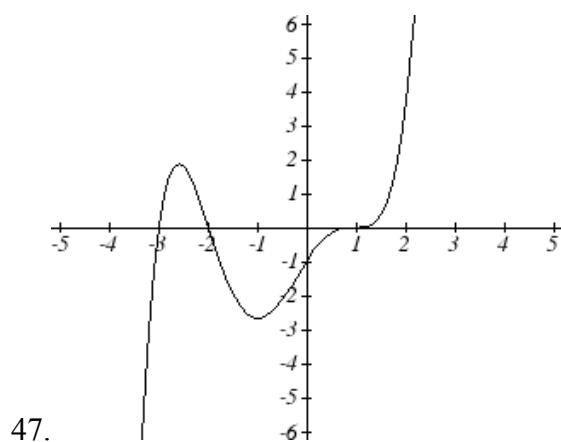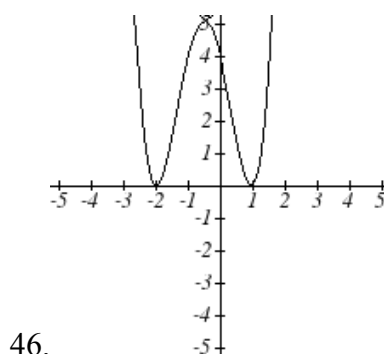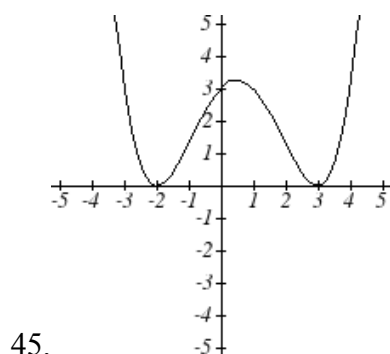
51. A rectangle is inscribed with its base on the x axis and its upper corners on the parabola $y = 5 - x^2$. What are the dimensions of such a rectangle with the greatest possible area?
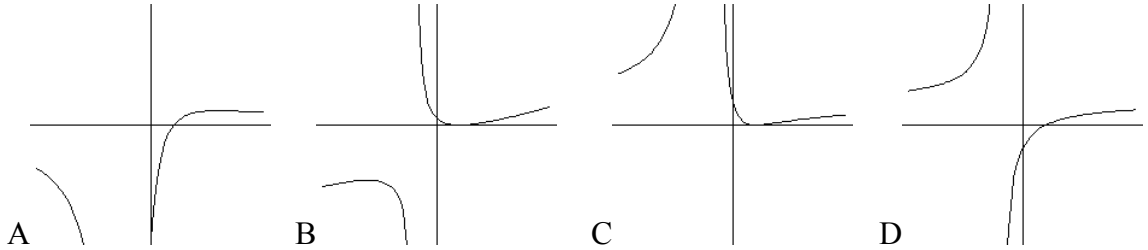
52. A rectangle is inscribed with its base on the x axis and its upper corners on the curve $y = 16 - x^4$. What are the dimensions of such a rectangle with the greatest possible area?

Section 3.4 Exercises

Match each equation form with one of the graphs

1. $f(x) = \dfrac{x-A}{x-B}$ 2. $g(x) = \dfrac{(x-A)^2}{x-B}$ 3. $h(x) = \dfrac{x-A}{(x-B)^2}$ 4. $k(x) = \dfrac{(x-A)^2}{(x-B)^2}$

A   B   C   D

For each function, find the x intercepts, the vertical intercept, the vertical asymptotes, and the horizontal asymptote. Use that information to sketch a graph.

5. $p(x) = \dfrac{2x-3}{x+4}$

6. $q(x) = \dfrac{x-5}{3x-1}$

7. $s(x) = \dfrac{4}{(x-2)^2}$

8. $r(x) = \dfrac{5}{(x+1)^2}$

9. $f(x) = \dfrac{3x^2 - 14x - 5}{3x^2 + 8x - 16}$

10. $g(x) = \dfrac{2x^2 + 7x - 15}{3x^2 - 14 + 15}$

11. $a(x) = \dfrac{x^2 + 2x - 3}{x^2 - 1}$

12. $b(x) = \dfrac{x^2 - x - 6}{x^2 - 4}$

13. $h(x) = \dfrac{2x^2 + x - 1}{x - 4}$

14. $k(x) = \dfrac{2x^2 - 3x - 20}{x - 5}$

15. $n(x) = \dfrac{3x^2 + 4x - 4}{x^3 - 4x^2}$

16. $m(x) = \dfrac{5 - x}{2x^2 + 7x + 3}$

17. $w(x) = \dfrac{(x-1)(x+3)(x-5)}{(x+2)^2 (x-4)}$

18. $z(x) = \dfrac{(x+2)^2 (x-5)}{(x-3)(x+1)(x+4)}$

Write an equation for a rational function with the given characteristics

19. Vertical asymptotes at $x = 5$ and $x = -5$

    x intercepts at $(2,0)$ and $(-1,0)$ y intercept at $(0,4)$

20. Vertical asymptotes at $x = -4$ and $x = -1$

    x intercepts at $(1,0)$ and $(5,0)$ y intercept at $(0,7)$

21. Vertical asymptotes at $x = -4$ and $x = -5$

    x intercepts at $(4,0)$ and $(-6,0)$ Horizontal asymptote at $y = 7$

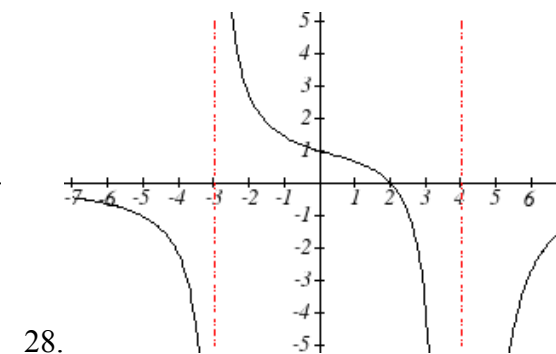22. Vertical asymptotes at $x = -3$ and $x = 6$

    x intercepts at $(-2,0)$ and $(1,0)$ Horizontal asymptote at $y = -2$

23. Vertical asymptote at $x = -1$

    Double zero at $x = 2$ y intercept at $(0,2)$

24. Vertical asymptote at $x = 3$

    Double zero at $x = 1$ y intercept at $(0,4)$

Write an equation for the function graphed
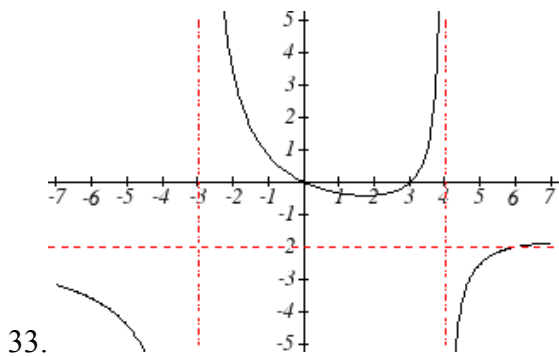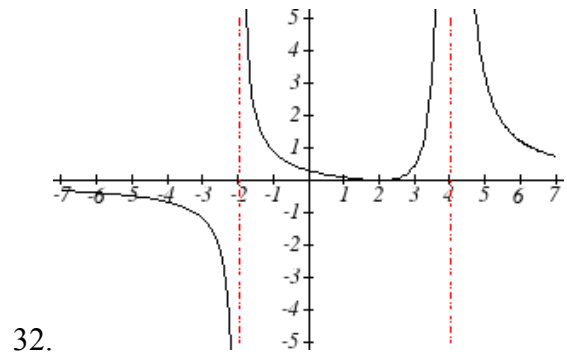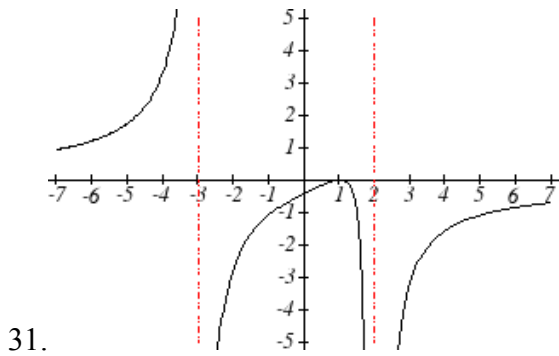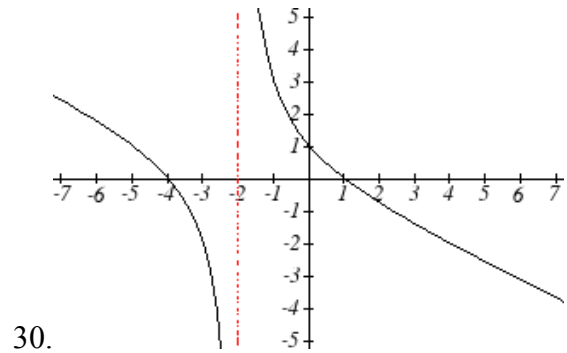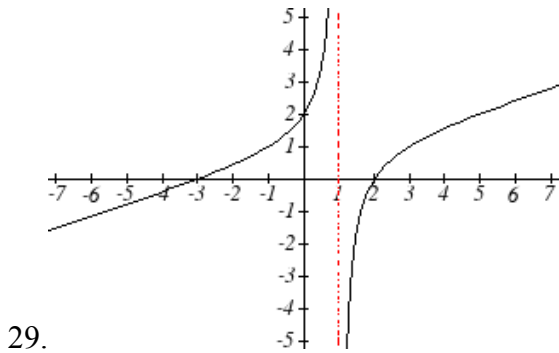

25.

26.

27.

28.

Write an equation for the function graphed

29.

30.

31.

32.

33.

34.

35.

36.
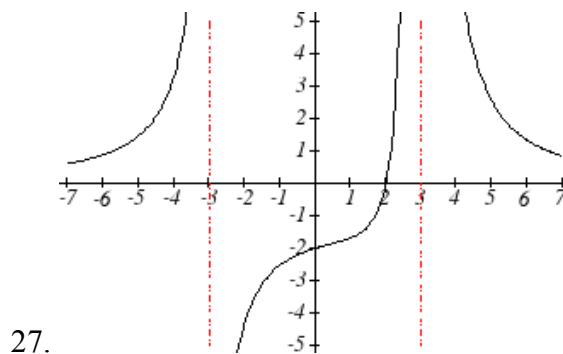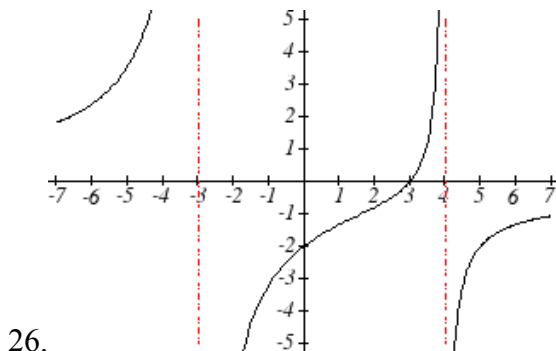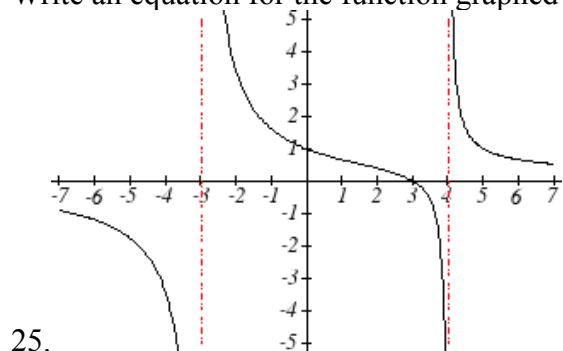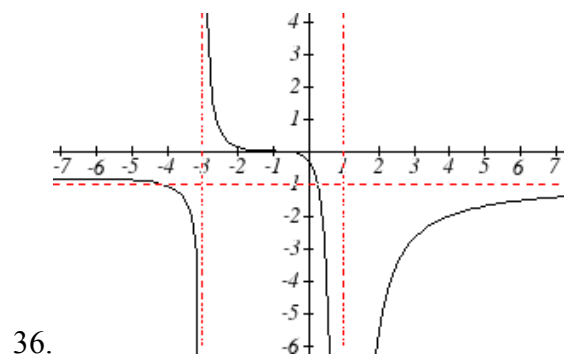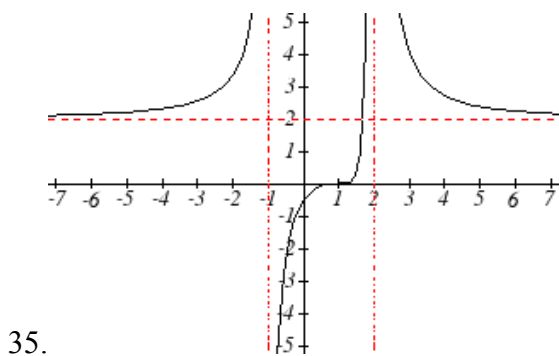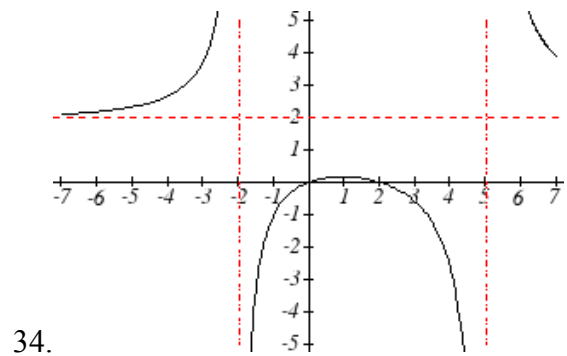
Write an equation for the function graphed
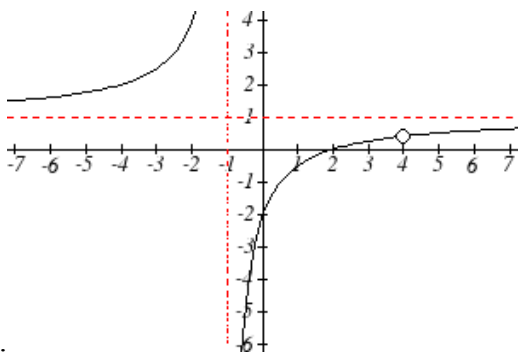
37.
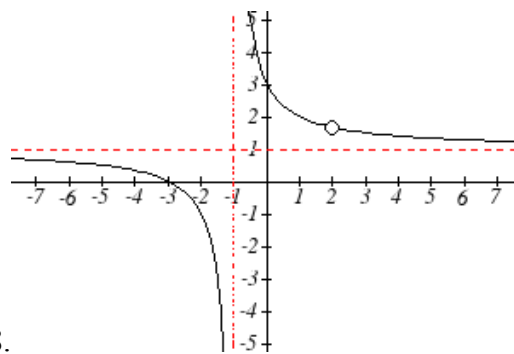
38.

39. A scientist has a beaker containing 20 mL of a solution containing 20% acid. To dilute this, she adds pure water.
    a. Write an equation for the concentration in the beaker after adding n mL of water
    b. Find the concentration if 10 mL of water is added
    c. How many mL of water must be added to obtain a 4% solution?
    d. What is the behavior as $n \to \infty$, and what is the physical significance of this?

40. A scientist has a beaker containing 30 mL of a solution containing 3 grams of potassium hydroxide. To this, she mixes a solution containing 8 milligrams per mL of potassium hydroxide.
    a. Write an equation for the concentration in the tank after adding n mL of the second solution.
    b. Find the concentration if 10 mL of the second solution is added
    c. How many mL of water must be added to obtain a 50 mg/mL solution?
    d. What is the behavior as $n \to \infty$, and what is the physical significance of this?

41. Oscar is hunting magnetic fields with his gauss meter, a device for measuring the strength and polarity of magnetic fields. The reading on the meter will increase as Oscar gets closer to a magnet. Oscar is in a long hallway at the end of which is a room containing an extremely strong magnet. When he is far down the hallway from the room, the meter reads a level of 0.2. He then walks down the hallway and enters the room. When he has gone 6 feet into the room, the meter reads 2.3. Eight feet into the room, the meter reads 4.4. [UW]
    a. Give a rational model of form $m(x) = \dfrac{ax+b}{cx+d}$ relating the meter reading $m(x)$ to how many feet x Oscar has gone into the room.
    b. How far must he go for the meter to reach 10? 100?
    c. Considering your function from part (a) and the results of part (b), how far into the room do you think the magnet is?

42. The more you study for a certain exam, the better your performance on it. If you study for 10 hours, your score will be 65%. If you study for 20 hours, your score will be 95%. You can get as close as you want to a perfect score just by studying long enough. Assume your percentage score, $p(n)$, is a function of the number of hours, n, that you study in the form $p(n) = \dfrac{an+b}{cn+d}$. If you want a score of 80%, how long do you need to study? [UW]

43. A street light is 10 feet North of a straight bike path that runs East-West. Olav is bicycling down the path at a rate of 15 MPH. At noon, Olav is 33 feet West of the point on the bike path closest to the street light. (See the picture).
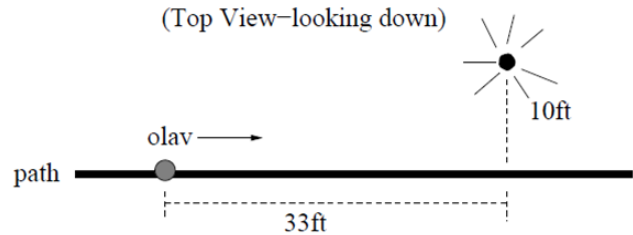
The relationship between the intensity C of light (in candlepower) and the distance d (in feet) from the light source is given by $C = \dfrac{k}{d^2}$, where k is a constant depending on the light source. [UW]

    a.   From 20 feet away, the street light has an intensity of 1 candle. What is k?
    b.   Find a function which gives the intensity of the light shining on Olav as a function of time, in seconds.
    c.   When will the light on Olav have maximum intensity?
    d.   When will the intensity of the light be 2 candles?

Section 3.5 Exercises

For each function, find a domain on which the function is one-to-one and non-decreasing, then find an inverse of the function on this domain.

1. $f(x) = (x-4)^2$

2. $f(x) = (x+2)^2$

3. $f(x) = 12 - x^2$

4. $f(x) = 9 - x^2$

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

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

Find the inverse of each function

7. $f(x) = 9 + \sqrt{4x-4}$

8. $f(x) = \sqrt{6x-8} + 5$

9. $f(x) = 9 + 2\sqrt[3]{x}$

10. $f(x) = 3 - \sqrt[3]{x}$

11. $f(x) = \dfrac{2}{x+8}$

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

13. $f(x) = \dfrac{x+3}{x+7}$

14. $f(x) = \dfrac{x-2}{x+7}$

15. $f(x) = \dfrac{3x+4}{5-4x}$

16. $f(x) = \dfrac{5x+1}{2-5x}$

Police use the formula $v = \sqrt{20L}$ to estimate the speed of a car, v, in miles per hour, based on the length, L, in feet, of its skid marks when suddenly braking on a dry, asphalt road.

17. At the scene of an accident, a police officer measures a car's skid marks to be 215 feet long. Approximately how fast was the car traveling?

18. At the scene of an accident, a police officer measures a car's skid marks to be 135 feet long. Approximately how fast was the car traveling?

The formula $v = \sqrt{2.7r}$ models the maximum safe speed, v, in miles per hour, at which a car can travel on a curved road with radius of curvature r, in feet.

19. A highway crew measures the radius of curvature at an exit ramp on a highway as 430 feet. What is the maximum safe speed?

20. A highway crew measures the radius of curvature at a tight corner on a highway as 900 feet. What is the maximum safe speed?

21. A drainage canal has a cross-
    section in the shape of a parabola.
    Suppose that the canal is 10 feet
    deep and 20 feet wide at the top. If
    the water depth in the ditch is 5
    feet, how wide is the surface of the
    water in the ditch? [UW]
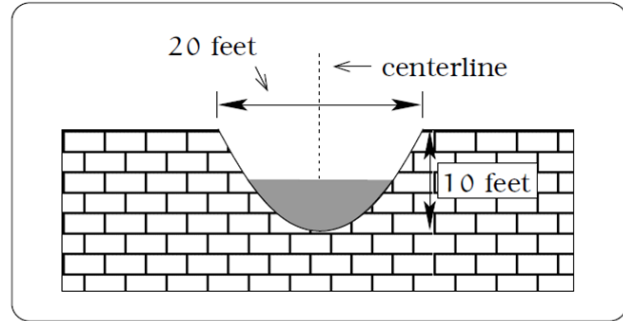
22. Brooke is located 5 miles out from the
    nearest point A along a straight shoreline in
    her seakayak. Hunger strikes and she wants
    to make it to Kono's for lunch; see picture.
    Brooke can paddle 2 mph and walk 4 mph.
    [UW]
    a. If she paddles along a straight line
       course to the shore, find an
       expression that computes the total time to reach lunch in terms of the location
       where Brooke beaches the boat.
    b. Determine the total time to reach Kono's if she paddles directly to the point A.
    c. Determine the total time to reach Kono's if she paddles directly to Kono's.
    d. Do you think your answer to b or c is the minimum time required for Brooke
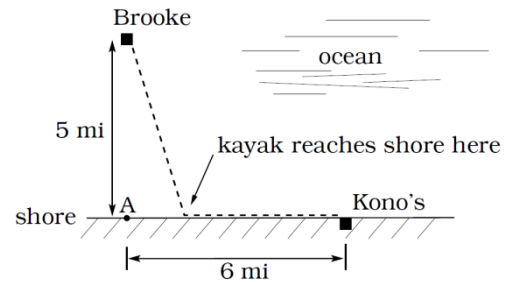   to reach lunch?
    e. Determine the total time to reach Kono's if she paddles directly to a point on
       the shore half way between point A and Kono's. How does this time compare
       to the times in parts b or c? Do you need to modify your answer to part d?

23. Clovis is standing at the edge of a cliff, which slopes 4 feet downward from him for
    every 1 horizontal foot. He launches a small model rocket from where he is standing.
    With the origin of the coordinate system located where he is standing, and the x-axis
    extending horizontally, the path of the rocket is described by the formula
    $y = -2x^2 + 120x$. [UW]
    a. Give a function $h = f(x)$ relating the height h of the rocket above the sloping
       ground to its x-coordinate.
    b. Find the maximum height of the rocket above the sloping ground. What is its
       x-coordinate when it is at its maximum height?
    c. Clovis measures its height h of the rocket above the sloping ground while it is
       going up. Give a function $x = g(h)$ relating the x-coordinate of the rocket to
       h.
    d. Does this function still work when the rocket is going down? Explain.

24. A trough has a semicircular cross section with a radius of 5 feet. Water starts flowing into the trough in such a way that the depth of the water is increasing at a rate of 2 inches per hour. [UW]

water

5 ft

cross-section of trough
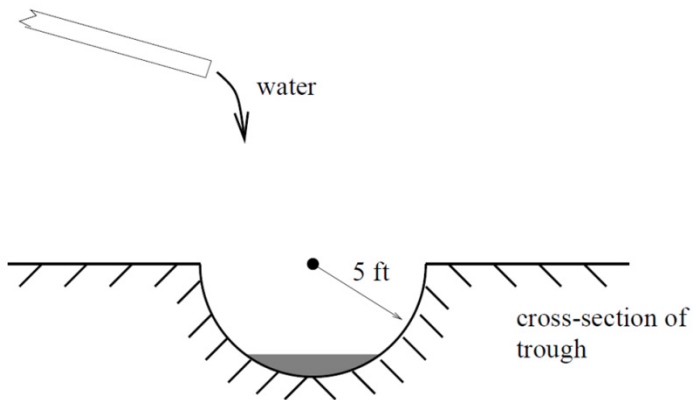
   a. Give a function $w = f(t)$ relating the width w of the surface of the water to the time t, in hours. Make sure to specify the domain and compute the range too.

   b. After how many hours will the surface of the water have width of 6 feet?

   c. Give a function $t = f^{-1}(w)$ relating the time to the width of the surface of the water. Make sure to specify the domain and compute the range too.

Section 4.1 Exercises

For each table below, could the table represent a function that is linear, exponential, or neither?

1.
x	1	2	3	4
f(x)	70	40	10	-20

2.
x	1	2	3	4
g(x)	40	32	26	22

3.
x	1	2	3	4
h(x)	70	49	34.3	24.01

4.
x	1	2	3	4
k(x)	90	80	70	60

5.
x	1	2	3	4
m(x)	80	61	42.9	25.61

6.
x	1	2	3	4
n(x)	90	81	72.9	65.61

7. A population numbers 11,000 organisms initially and grows by 8.5% each year. Write an exponential model for the population.

8. A population is currently 6,000 and has been increasing by 1.2% each day. Write an exponential model for the population.

9. The fox population in a certain region has an annual growth rate of 9 percent per year. It is estimated that the population in the year 2010 was 23,900. Estimate the fox population in the year 2018.

10. The amount of area covered by blackberry bushes in a park has been growing by 12% each year. It is estimated that the area covered in 2009 was 4,500 square feet. Estimate area that will be covered in 2020.

11. A vehicle purchased for $32,500 depreciates at a constant rate of 5% each year. Determine the approximate value of the vehicle 12 years after purchase.

12. A business purchases $125,000 of office furniture which depreciates at a constant rate of 12% each year. Find the residual value of the furniture 6 years after purchase.

Find an equation for an exponential passing through the two points
13. $(0,6), (3,750)$ 14. $(0,3), (2,75)$

15. $(0,2000), (2,20)$ 16. $(0,9000), (3,72)$

17. $\left(-1,\dfrac{3}{2}\right),(3,24)$ 18. $\left(-1,\dfrac{2}{5}\right),(1,10)$

19. $(-2,6),(3,1)$ 20. $(-3,4),(3,2)$

21. $(3,1),(5,4)$ 22. $(2,5),(6,9)$

23. A radioactive substance decays exponentially. A scientist begins with 100 milligrams
   of a radioactive substance. After 35 hours, 50 mg of the substance remains. How
   many milligrams will remain after 54 hours?

24. A radioactive substance decays exponentially. A scientist begins with 110 milligrams
   of a radioactive substance. After 31 hours, 55 mg of the substance remains. How
   many milligrams will remain after 42 hours?

25. A house was valued at $110,000 in the year 1985. The value appreciated to $145,000
   by the year 2005. What was the annual growth rate between 1985 and 2005?
   Assume that the house value continues to grow by the same percentage. What will the
   value equal in the year 2010?

26. An investment was valued at $11,000 in the year 1995. The value appreciated to
   $14,000 by the year 2008. What was the annual growth rate between 1995 and 2008?
   Assume that the value continues to grow by the same percentage. What will the value
   equal in the year 2012?

27. A car was valued at $38,000 in the year 2003. The value depreciated to $11,000 by
   the year 2009. Assume that the car value continues to drop by the same percentage.
   What will the value be in the year 2013?

28. A car was valued at $24,000 in the year 2006. The value depreciated to $20,000 by
   the year 2009. Assume that the car value continues to drop by the same percentage.
   What will the value be in the year 2014?

29. If 4000 dollars is invested in a bank account at an interest rate of 7 per cent per year,
   find the amount in the bank after 9 years if interest is compounded annually,
   quarterly, monthly, and continuously.

30. If 6000 dollars is invested in a bank account at an interest rate of 9 per cent per year, find the amount in the bank after 5 years if interest is compounded annually, quarterly, monthly, and continuously.

31. Find the annual percentage yield (APY) for a savings account with annual percentage rate of 3% compounded quarterly.

32. Find the annual percentage yield (APY) for a savings account with annual percentage rate of 5% compounded monthly.

33. A population of bacteria is growing according to the equation $P(t)=1600e^{0.21t}$, with t measured in years. Estimate when the population will exceed 7569.

34. A population of bacteria is growing according to the equation $P(t)=1200e^{0.17t}$, with t measured in years. Estimate when the population will exceed 3443.

35. In 1968, the U.S. minimum wage was \$1.60 per hour. In 1976, the minimum wage was \$2.30 per hour. Assume the minimum wage grows according to an exponential model $w(t)$, where t represents the time in years after 1960. [UW]
    a. Find a formula for $w(t)$.
    b. What does the model predict for the minimum wage in 1960?
    c. If the minimum wage was \$5.15 in 1996, is this above, below or equal to what the model predicts.

36. In 1989, research scientists published a model for predicting the cumulative number of AIDS cases (in thousands) reported in the United States: $a(t)=155\left(\dfrac{t-1980}{10}\right)^{3}$, where t is the year. This paper was considered a "relief", since there was a fear the correct model would be of exponential type. Pick two data points predicted by the research model $a(t)$ to construct a new exponential model $b(t)$ for the number of cumulative AIDS cases. Discuss how the two models differ and explain the use of the word "relief." [UW]

37. You have a chess board as pictured, with squares numbered 1 through 64. You also have a huge change jar with an unlimited number of dimes. On the first square you place one dime. On the second square you stack 2 dimes. Then you continue, always doubling the number from the previous square. [UW]

    a. How many dimes will you have stacked on the 10th square?
    b. How many dimes will you have stacked on the nth square?
    c. How many dimes will you have stacked on the 64th square?
    d. Assuming a dime is 1 mm thick, how high will this last pile be?
    e. The distance from the earth to the sun is approximately 150 million km. Relate the height of the last pile of dimes to this distance.

						63	64
						10	9
1	2	3					8

Section 4.2 Exercises

Match each equation with one of the graphs below

1. $f(x) = 2(0.69)^x$

2. $f(x) = 2(1.28)^x$

3. $f(x) = 2(0.81)^x$

4. $f(x) = 4(1.28)^x$

5. $f(x) = 2(1.59)^x$

6. $f(x) = 4(0.69)^x$
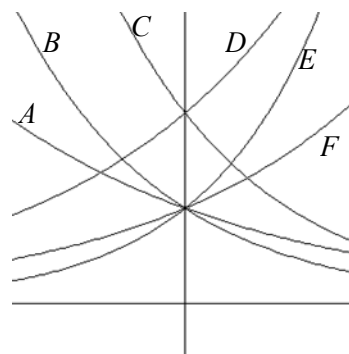
If all the graphs to the right have equations with form
$f(x) = ab^x$

7. Which graph has the largest value for b?

8. Which graph has the smallest value for b?

9. Which graph has the largest value for a?

10. Which graph has the smallest value for a?
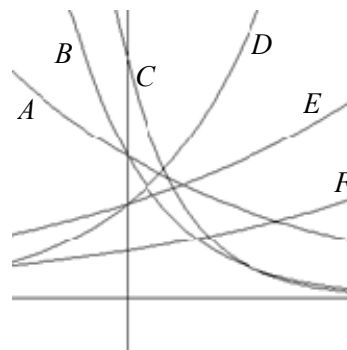
Sketch a graph of each of the following transformations of $f(x) = 2^x$

11. $f(x) = 2^{-x}$

12. $g(x) = -2^x$

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

14. $f(x) = 2^x - 4$

15. $f(x) = 2^{x-2}$

16. $k(x) = 2^{x-3}$

Starting with the graph of $f(x) = 4^x$, write the equation of the graph that results from

17. Shifting $f(x)$ 4 units upwards

18. Shifting $f(x)$ 3 units downwards

19. Shifting $f(x)$ 2 units left

20. Shifting $f(x)$ 5 units right

21. Reflecting $f(x)$ about the x-axis

22. Reflecting $f(x)$ about the y-axis

Describe the long run behavior, as $x \to \infty$ and $x \to -\infty$ of each function

23. $f(x) = -5(4^x) - 1$

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

25. $f(x) = 3\left(\dfrac{1}{2}\right)^x - 2$

26. $f(x) = 4\left(\dfrac{1}{4}\right)^x + 1$

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

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

Find an equation for each graph as a transformation of $f(x) = 2^x$

29.

30.

31.

32.
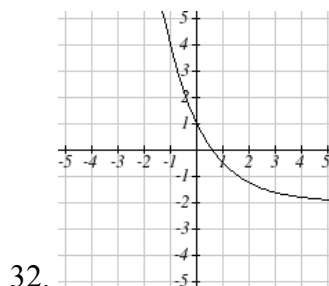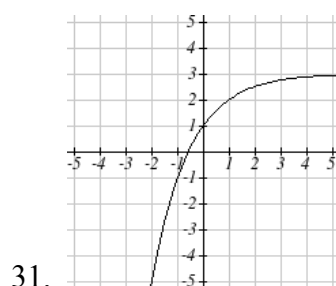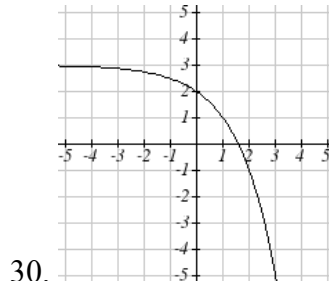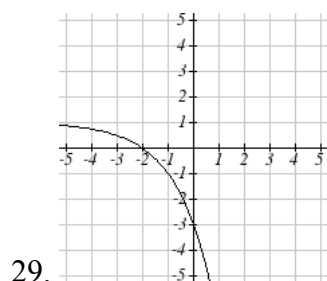
Find an equation for the exponential graphed.

33.

34.

35.

36.
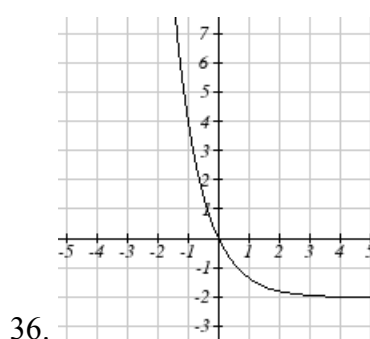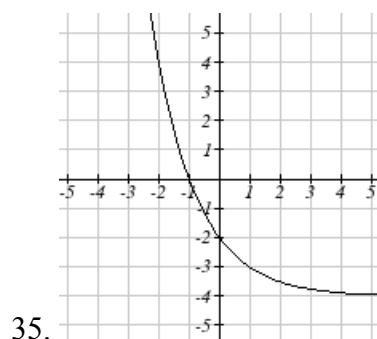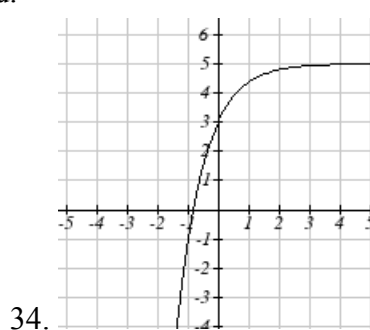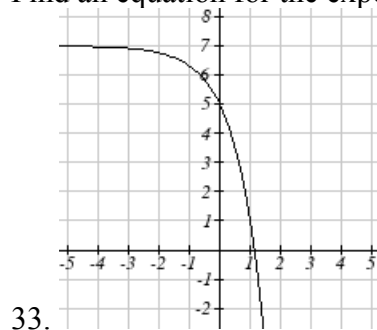
Section 4.3 Exercises

Rewrite each equation in exponential form

1. $\log_4(q) = m$ 2. $\log_3(t) = k$ 3. $\log_a(b) = c$ 4. $\log_p(z) = u$

5. $\log(v) = t$ 6. $\log(r) = s$ 7. $\ln(w) = n$ 8. $\ln(x) = y$

Rewrite each equation in logarithmic form.

9. $4^x = y$ 10. $5^y = x$ 11. $c^d = k$ 12. $n^z = L$

13. $10^a = b$ 14. $10^p = v$ 15. $e^k = h$ 16. $e^y = x$

Solve for x.

17. $\log_3(x) = 2$ 18. $\log_4(x) = 3$ 19. $\log_2(x) = -3$ 20. $\log_5(x) = -1$

21. $\log(x) = 3$ 22. $\log(x) = 5$ 23. $\ln(x) = 2$ 24. $\ln(x) = -2$

Simplify each expression using logarithm properties

25. $\log_5(25)$ 26. $\log_2(8)$ 27. $\log_3\left(\dfrac{1}{27}\right)$ 28. $\log_6\left(\dfrac{1}{36}\right)$

29. $\log_6\left(\sqrt{6}\right)$ 30. $\log_5\left(\sqrt[3]{5}\right)$ 31. $\log(10,000)$ 32. $\log(100)$

33. $\log(0.001)$ 34. $\log(0.00001)$ 35. $\ln\left(e^{-2}\right)$ 36. $\ln\left(e^3\right)$

Evaluate using your calculator

37. $\log(0.04)$ 38. $\log(1045)$ 39. $\ln(15)$ 40. $\ln(0.02)$

Solve each equation for the variable

41. $5^x = 14$ 42. $3^x = 23$ 43. $7^x = \dfrac{1}{15}$ 44. $3^x = \dfrac{1}{4}$

45. $e^{5x} = 17$ 46. $e^{3x} = 12$ 47. $3^{4x-5} = 38$ 48. $4^{2x-3} = 44$

49. $1000(1.03)^t = 5000$ 50. $200(1.06)^t = 550$

51. $3(1.04)^{3t} = 8$ 52. $2(1.08)^{4t} = 7$

53. $50e^{-0.12t} = 10$ 54. $10e^{-0.03t} = 4$

55. $10 - 8\left(\dfrac{1}{2}\right)^x = 5$ 56. $100 - 100\left(\dfrac{1}{4}\right)^x = 70$

Convert the equation into continuous growth $f(t) = ae^{kt}$ form

57. $f(t) = 300(0.91)^t$

58. $f(t) = 120(0.07)^t$

59. $f(t) = 10(1.04)^t$

60. $f(t) = 1400(1.12)^t$

Convert the equation into annual growth $f(t) = ab^t$ form

61. $f(t) = 150e^{0.06t}$

62. $f(t) = 100e^{0.12t}$

63. $f(t) = 50e^{-0.012t}$

64. $f(t) = 80e^{-0.85t}$

65. The population of Kenya was 39.8 million in 2009 and has been growing by about 2.6% each year. If this trend continues, when will the population exceed 45 million?

66. The population of Algeria was 34.9 million in 2009 and has been growing by about 1.5% each year. If this trend continues, when will the population exceed 45 million?

67. The population of Seattle grew from 563,374 in 2000 to 608,660 in 2010. If the population continues to grow exponentially at the same rate, when will the population exceed 1 million people?

68. The median household income (adjusted for inflation) in Seattle grew from $42,948 in 1990 to $45,736 in 2000. If it continues to grow exponentially at the same rate, when will median income exceed $50,000?

69. A scientist begins with 100 mg of a radioactive substance. After 4 hours, it has decayed to 80 mg. How long will it take to decay to 15 mg?

70. A scientist begins with 100 mg of a radioactive substance. After 6 days, it has decayed to 60 mg. How long will it take to decay to 10 mg?

71. If $1000 is invested in an account earning 3% compounded monthly, how long will it take the account to grow in value to $1500?

72. If $1000 is invested in an account earning 2% compounded quarterly, how long will it take the account to grow in value to $1300?

Section 4.4 Exercises

Simplify using logarithm properties to a single logarithm

1. $\log_3(28) - \log_3(7)$

2. $\log_3(32) - \log_3(4)$

3. $-\log_3\left(\dfrac{1}{7}\right)$

4. $-\log_4\left(\dfrac{1}{5}\right)$

5. $\log_3\left(\dfrac{1}{10}\right) + \log_3(50)$

6. $\log_4(3) + \log_4(7)$

7. $\dfrac{1}{3}\log_7(8)$

8. $\dfrac{1}{2}\log_5(36)$

9. $\log(2x^4) + \log(3x^5)$

10. $\ln(4x^2) + \ln(3x^3)$

11. $\ln(6x^9) - \ln(3x^2)$

12. $\log(12x^4) - \log(4x)$

13. $2\log(x) + 3\log(x+1)$

14. $3\log(x) + 2\log(x^2)$

15. $\log(x) - \dfrac{1}{2}\log(y) + 3\log(z)$

16. $2\log(x) + \dfrac{1}{3}\log(y) - \log(z)$

Use logarithm properties to expand each expression

17. $\log\left(\dfrac{x^{15}y^{13}}{z^{19}}\right)$

18. $\log\left(\dfrac{a^2b^3}{c^5}\right)$

19. $\ln\left(\dfrac{a^{-2}}{b^{-4}c^5}\right)$

20. $\ln\left(\dfrac{a^{-2}b^3}{c^{-5}}\right)$

21. $\log\left(\sqrt{x^3y^{-4}}\right)$

22. $\log\left(\sqrt{x^{-3}y^2}\right)$

23. $\ln\left(y\sqrt{\dfrac{y}{1-y}}\right)$

24. $\ln\left(\dfrac{x}{\sqrt{1-x^2}}\right)$

25. $\log\left(x^2y^3\sqrt[3]{x^2y^5}\right)$

26. $\log\left(x^3y^4\sqrt[7]{x^3y^9}\right)$

Solve each equation for the variable

27. $4^{4x-7} = 3^{9x-6}$

28. $2^{2x-5} = 7^{3x-7}$

29. $17(1.14)^x = 19(1.16)^x$

30. $20(1.07)^x = 8(1.13)^x$

31. $5e^{0.12t} = 10e^{0.08t}$

32. $3e^{0.09t} = e^{0.14t}$

33. $\log_2(7x+6) = 3$

34. $\log_3(2x+4) = 2$

35. $2\ln(3x)+3 = 1$

36. $4\ln(5x)+5 = 2$

37. $\log(x^3) = 2$

38. $\log(x^5) = 3$

39. $\log(x)+\log(x+3) = 3$

40. $\log(x+4)+\log(x) = 9$

41. $\log(x+4)-\log(x+3) = 1$

42. $\log(x+5)-\log(x+2) = 2$

43. $\log_6(x^2)-\log_6(x+1) = 1$

44. $\log_3(x^2)-\log_3(x+2) = 5$

45. $\log(x+12) = \log(x)+\log(12)$

46. $\log(x+15) = \log(x)+\log(15)$

47. $\ln(x)+\ln(x-3) = \ln(7x)$

48. $\ln(x)+\ln(x-6) = \ln(6x)$

Section 4.5 Exercises

For each function, find the domain and the vertical asymptote
1. $f(x) = \log(x-5)$ 2. $f(x) = \log(x+2)$

3. $f(x) = \ln(3-x)$ 4. $f(x) = \ln(5-x)$

5. $f(x) = \log(3x+1)$ 6. $f(x) = \log(2x+5)$

7. $f(x) = 3\log(-x) + 2$ 8. $f(x) = 2\log(-x) + 1$

Sketch a graph of each pair of function
9. $f(x) = \log(x), g(x) = \ln(x)$ 10. $f(x) = \log_2(x), g(x) = \log_4(x)$

Sketch each transformation
11. $f(x) = 2\log(x)$ 12. $f(x) = 3\ln(x)$

13. $f(x) = \ln(-x)$ 14. $f(x) = -\log(x)$

15. $f(x) = \log_2(x+2)$ 16. $f(x) = \log_3(x+4)$

Write an equation for the transformed logarithm graph shown

17.

18.

19.

20.

Write an equation for the transformed logarithm graph shown

21.

22.

23.

24.
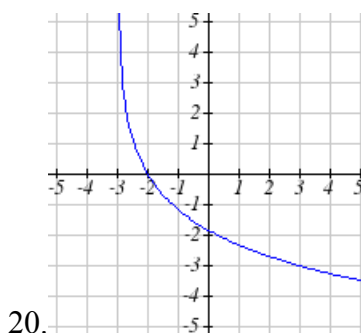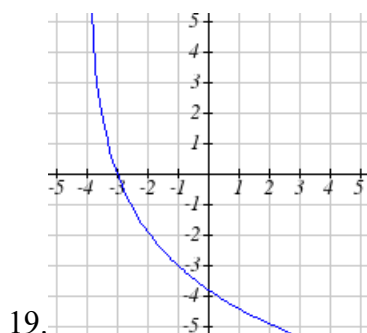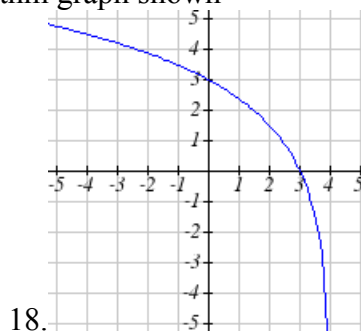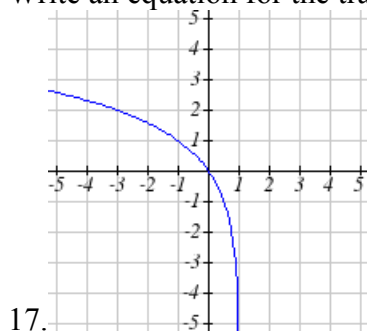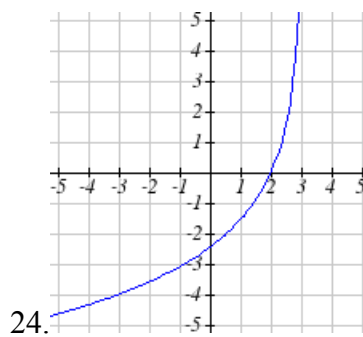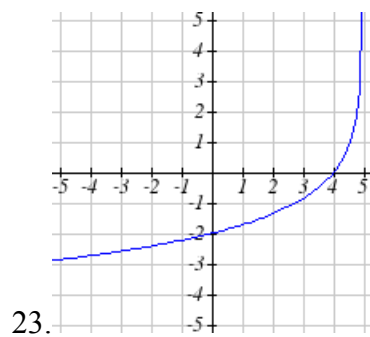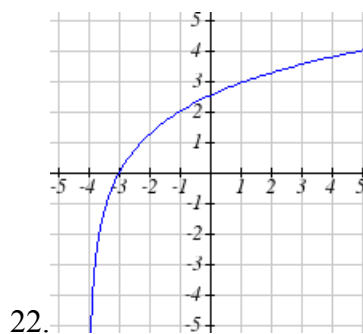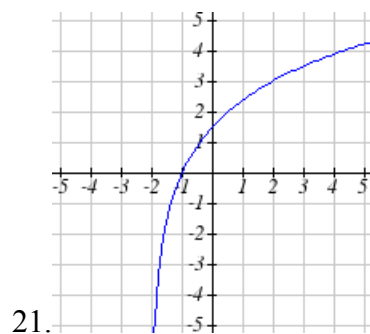
Section 4.6 Exercises

1. You go to the doctor and he gives you 13 milligrams of radioactive dye. After 12 minutes, 4.75 milligrams of dye remain in your system. To leave the doctor's office, you must pass through a radiation detector without sounding the alarm. If the detector will sound the alarm if more than 2 milligrams of the dye are in your system, how long will your visit to the doctor take, assuming you were given the dye as soon as you arrived?

2. You take 200 milligrams of a headache medicine, and after 4 hours, 120 milligrams remain in your system. If the effects of the medicine wear off when less than 80 milligrams remain, when will you need to take a second dose?

3. The half-life of Radium-226 is 1590 years. If a sample contains 200 mg, how many milligrams will remain after 1000 years?

4. The half-life of Fermium-253 is 3 days. If a sample contains 100 mg, how many milligrams will remain after 1 week?

5. The half-life of Erbium-165 is 10.4 hours. After 24 hours a sample has been reduced to a mass of 2 mg. What was the initial mass of the sample, and how much will remain after 3 days?

6. The half-life of Nobelium-259 is 58 minutes. After 3 hours a sample has been reduced to a mass of 10 mg. What was the initial mass of the sample, and how much will remain after 8 hours?

7. A scientist begins with 250 grams of a radioactive substance. After 225 minutes, the sample has decayed to 32 grams. Find the half-life of this substance.

8. A scientist begins with 20 grams of a radioactive substance. After 7 days, the sample has decayed to 17 grams. Find the half-life of this substance.

9. A wooden artifact from an archeological dig contains 60 percent of the carbon-14 that is present in living trees. How long ago was the artifact made? (the half-life of carbon-14 is 5730 years)

10. A wooden artifact from an archeological dig contains 15 percent of the carbon-14 that is present in living trees. How long ago was the artifact made? (the half-life of carbon-14 is 5730 years)

11. A bacteria culture initially contains 1500 bacteria and doubles every half hour. Find the size of the population after: a) 2 hours, b) 100 minutes

12. A bacteria culture initially contains 2000 bacteria and doubles every half hour. Find the size of the population after: a) 3 hours, b) 80 minutes

13. The count of bacteria in a culture was 800 after 10 minutes and 1800 after 40 minutes.
    a. What was the initial size of the culture?
    b. Find the doubling period.
    c. Find the population after 105 minutes.
    d. When will the population reach 11000?

14. The count of bacteria in a culture was 600 after 20 minutes and 2000 after 35 minutes.
    a. What was the initial size of the culture?
    b. Find the doubling period.
    c. Find the population after 170 minutes.
    d. When will the population reach 12000?

15. Find the time required for an investment to double in value if invested in an account paying 3% compounded quarterly.

16. Find the time required for an investment to double in value if invested in an account paying 4% compounded monthly

17. The number of crystals that have formed after t hours is given by $n(t) = 20e^{0.013t}$. How long does it take the number of crystals to double?

18. The number of building permits in Pasco t years after 1992 roughly followed the equation $n(t) = 400e^{0.143t}$. What is the doubling time?

19. A turkey is pulled from the oven when the internal temperature is 165° Fahrenheit, and is allowed to cool in a 75° room. If the temperature of the turkey is 145° after half an hour,
    a. What will the temperature be after 50 minutes?
    b. How long will it take the turkey to cool to 110°?

20. A cup of coffee is poured at 190° Fahrenheit, and is allowed to cool in a 70° room. If the temperature of the coffee is 170° after half an hour,
    a.   What will the temperature be after 70 minutes?
    b.   How long will it take the coffee to cool to 120°?

21. The population of fish in a farm-stocked lake after t years could be modeled by the equation $P(t) = \dfrac{1000}{1+9e^{-0.6t}}$.
    a.   Sketch a graph of this equation
    b.   What is the initial population of fish?
    c.   What will the population be after 2 years?
    d.   How long will it take for the population to reach 900?

22. The number of people in a town that have heard rumor after t days can be modeled by the equation $N(t) = \dfrac{500}{1+49e^{-0.7t}}$.
    a.   Sketch a graph of this equation
    b.   How many people started the rumor?
    c.   How many people have heard the rumor after 3 days??
    d.   How long will it take 300 people to have heard the rumor?

Find the value of the number shown on each logarithmic scale

23.

24.

25.

26.
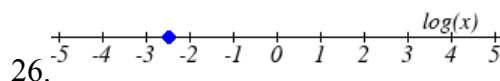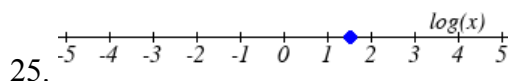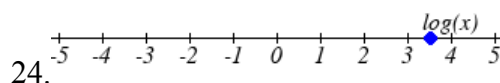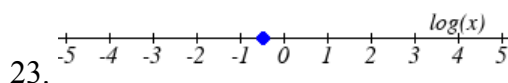
Plot each set of approximate values on a logarithmic scale
27. Intensity of sounds: Whisper: 10^{-10} W / m^2 , Vacuum: $10^{-4} W / m^2$, Jet: 10^2 W / m^2

28. Mass: Amoeba: $10^{-5} g$, Human: $10^5 g$, Statue of Liberty: $10^8 g$

29. The 1906 San Francisco earthquake had a magnitude of 7.9 on the MMS scale. At the same time there was an earthquake with magnitude 4.7 that caused only minor damage. How many times more intense was the San Francisco earthquake than the second one?

30. The 1906 San Francisco earthquake had a magnitude of 7.9 on the MMS scale. At the same time there was an earthquake with magnitude 6.5 that caused less damage. How many times more intense was the San Francisco earthquake than the second one?

31. One earthquake has magnitude 3.9. If a second earthquake has 750 times as much energy as the first, find the magnitude of the second quake.

32. One earthquake has magnitude 4.8. If a second earthquake has 1200 times as much energy as the first, find the magnitude of the second quake.

33. A colony of yeast cells is estimated to contain 10^6 cells at time t = 0. After collecting experimental data in the lab, you decide that the total population of cells at time t hours is given by the function $f(t) = 10^6 e^{0.495105t}$ [UW]
    a. How many cells are present after one hour?
    b. How long does it take of the population to double?.
    c. Cherie, another member of your lab, looks at your notebook and says: ...that formula is wrong, my calculations predict the formula for the number of yeast cells is given by the function. $f(t) = 10^6 (2.042727)^{0.693147t}$. Should you be worried by Cherie's remark?
    d. Anja, a third member of your lab working with the same yeast cells, took these two measurements: 7.246×10^6 cells after 4 hours; 16.504×10^6 cells after 6 hours. Should you be worried by Anja's results? If Anja's measurements are correct, does your model over estimate or under estimate the number of yeast cells at time t?

34. As light from the surface penetrates water, its intensity is diminished. In the clear waters of the Caribbean, the intensity is decreased by 15 percent for every 3 meters of depth. Thus, the intensity will have the form of a general exponential function. [UW]
    a. If the intensity of light at the water's surface is I_0, find a formula for $I(d)$, the intensity of light at a depth of d meters. Your formula should depend on I_0 and d.
    b. At what depth will the light intensity be decreased to 1% of its surface intensity?

35. Myoglobin and hemoglobin are oxygen carrying molecules in the human body. Hemoglobin is found inside red blood cells, which flow from the lungs to the muscles through the bloodstream. Myoglobin is found in muscle cells. The function

$Y = M(p) = \dfrac{p}{1+p}$ calculates the fraction of myoglobin saturated with oxygen at a

given pressure p torrs. For example, at a pressure of 1 torr, M(1) = 0.5, which means half of the myoglobin (i.e. 50%) is oxygen saturated. (Note: More precisely, you need to use something called the "partial pressure", but the distinction is not important for

this problem.) Likewise, the function $Y = H(p) = \dfrac{p^{2.8}}{26^{2.8} + p^{2.8}}$ calculates the fraction

of hemoglobin saturated with oxygen at a given pressure p.   [UW]

a. The graphs of $M(p)$ and $H(p)$ are given here on the domain $0 \le p \le 100$; which is which?
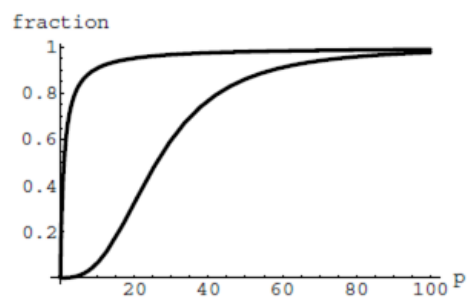
b. If the pressure in the lungs is 100 torrs, what is the level of oxygen saturation of the hemoglobin in the lungs?

c. The pressure in an active muscle is 20 torrs. What is the level of oxygen saturation of myoglobin in an active muscle? What is the level of hemoglobin in an active muscle?

d. Define the efficiency of oxygen transport at a given pressure p to be $M(p) - H(p)$. What is the oxygen transport efficiency at 20 torrs? At 40 torrs? At 60 torrs? Sketch the graph of $M(p) - H(p)$; are there conditions under which transport efficiency is maximized (explain)?

36. The length of some fish are modeled by a von Bertalanffy growth function. For Pacific halibut, this function has the form $L(t) = 200\left(1 - 0.957e^{-0.18t}\right)$ where $L(t)$ is the length (in centimeters) of a fish t years old.   [UW]

a. What is the length of a new-born halibut at birth?
b. Use the formula to estimate the length of a 6–year–old halibut.
c. At what age would you expect the halibut to be 120 cm long?
d. What is the practical (physical) significance of the number 200 in the formula for $L(t)$?

37. A cancerous cell lacks normal biological growth regulation and can divide continuously. Suppose a single mouse skin cell is cancerous and its mitotic cell cycle (the time for the cell to divide once) is 20 hours. The number of cells at time t grows according to an exponential model. [UW]
    a. Find a formula $C(t)$ for the number of cancerous skin cells after t hours.
    b. Assume a typical mouse skin cell is spherical of radius 50×10^{-4} cm. Find the combined volume of all cancerous skin cells after t hours. When will the volume of cancerous cells be 1 cm^3?

38. A ship embarked on a long voyage. At the start of the voyage, there were 500 ants in the cargo hold of the ship. One week into the voyage, there were 800 ants. Suppose the population of ants is an exponential function of time. [UW]
    a. How long did it take the population to double?
    b. How long did it take the population to triple?
    c. When were there be 10,000 ants on board?
    d. There also was an exponentially-growing population of anteaters on board. At the start of the voyage there were 17 anteaters, and the population of anteaters doubled every 2.8 weeks. How long into the voyage were there 200 ants per anteater?

39. The populations of termites and spiders in a certain house are growing exponentially. The house contains 100 termites the day you move in. After 4 days, the house contains 200 termites. Three days after moving in, there are two times as many termites as spiders. Eight days after moving in, there were four times as many termites as spiders. How long (in days) does it take the population of spiders to triple? [UW]

Section 4.7 Exercises

Graph each function on a semi-log scale, the find a formula for the linearized function in the form $\log(f(x)) = mx + b$

1. $f(x) = 4(1.3)^x$

2. $f(x) = 2(1.5)^x$

3. $f(x) = 10(0.2)^x$

4. $f(x) = 30(0.7)^x$

The graph below is on a semi-log scale, as indicated. Find an equation for the exponential function $y(x)$.

5.

6.

7.

8.
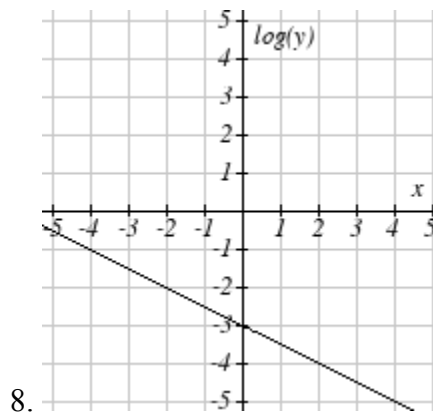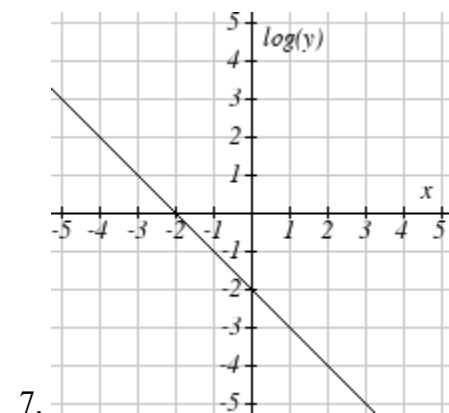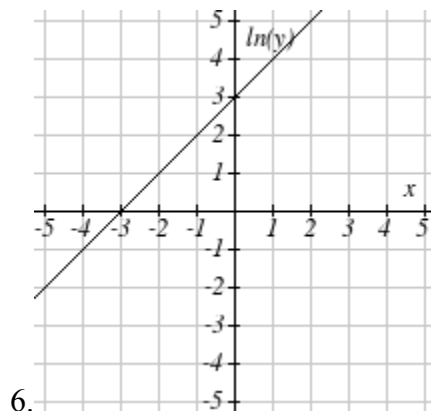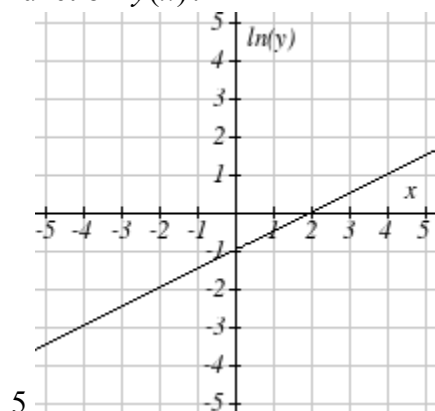
Use regression to find an exponential equation that best fits the data given.

9.

x	1	2	3	4	5	6
y	1125	1495	2310	3294	4650	6361

10.

x	1	2	3	4	5	6
y	643	829	920	1073	1330	1631

11.

x	1	2	3	4	5	6
y	555	383	307	210	158	122

12.

x	1	2	3	4	5	6
y	699	701	695	668	683	712

13. Total expenditures (in billions of dollars) in the US for nursing home care are shown below. Use regression to find an exponential equation that models the data. What does the model predict expenditures will be in 2015?

Year	1990	1995	2000	2003	2005	2008
Expenditure	53	74	95	110	121	138

14. Light intensity as it passes through decreases exponentially with depth. The data below shows the light intensity (in lumens) at various depths. Use regression to find an equation that models the data. What does the model predict the intensity will be at 25 feet?

Depth (ft)	3	6	9	12	15	18
Lumen	11.5	8.6	6.7	5.2	3.8	2.9

15. The average price of electricity (in cents per kilowatt hour) from 1990-2008 is given below. Determine if a linear or exponential model better fits the data, and use the better model to predict the price of electricity in 2014.

Year	1990	1992	1994	1996	1998	2000	2002	2004	2006	2008
Cost	7.83	8.21	8.38	8.36	8.26	8.24	8.44	8.95	10.40	11.26

16. The average cost of a loaf of white bread from 1986-2008 is given below. Determine if a linear or exponential model better fits the data, and use the better model to predict the price of a loaf of bread in 2016.

Year	1986	1988	1990	1995	1997	2000	2002	2004	2006	2008
Cost	0.57	0.66	0.70	0.84	0.88	0.99	1.03	0.97	1.14	1.42

Section 5.1 Exercises

1. Find the distance between the points (5,3) and (-1,-5)

2. Find the distance between the points (3,3) and (-3,-2)

3. Write the equation of the circle centered at (8 , -10) with radius 8.

4. Write the equation of the circle centered at (-9, 9) with radius 16.

5. Write the equation of the circle centered at (7, -2) that passes through (-10, 0).

6. Write the equation of the circle centered at (3, -7) that passes through (15, 13).

7. Write an equation for a circle where the points (2, 6) and (8, 10) lie along a diameter.

8. Write an equation for a circle where the points (-3, 3) and (5, 7) lie along a diameter.

9. Sketch a graph of $(x-2)^2 +(y+3)^2 =9$

10. Sketch a graph of $(x+1)^2 +(y-2)^2 =16$

11. Find the y intercept(s) of the circle with center (2, 3) with radius 3.

12. Find the x intercept(s) of the circle with center (2, 3) with radius 4.

13. At what point in the first quadrant does the line with equation $y=2x+5$ intersect a circle with radius 3 and center (0, 5)?

14. At what point in the first quadrant does the line with equation $y=x+2$ intersect the circle with radius 6 and center (0, 2)?

15. At what point in the second quadrant does the line with equation $y=2x+5$ intersect a circle with radius 3 and center (-2, 0)?

16. At what point in the first quadrant does the line with equation $y=x+2$ intersect the circle with radius 6 and center (-1,0)?

17. A small radio transmitter broadcasts in a 53 mile radius. If you drive along a straight line from a city 70 miles north of the transmitter to a second city 74 miles east of the transmitter, during how much of the drive will you pick up a signal from the transmitter?

18. A small radio transmitter broadcasts in a 44 mile radius. If you drive along a straight line from a city 56 miles south of the transmitter to a second city 53 miles west of the transmitter, during how much of the drive will you pick up a signal from the transmitter?

19. A tunnel connecting two portions of a space station has a circular cross-section of radius 15 feet. Two walkway decks are constructed in the tunnel. Deck A is along a horizontal diameter and another parallel Deck B is 2 feet below Deck A. Because the space station is in a weightless environment, you can walk vertically upright along Deck A, or vertically upside down along Deck B. You have been assigned to paint "safety stripes" on each deck level, so that a 6 foot person can safely walk upright along either deck. Determine the width of the "safe walk zone" on each deck. [UW]
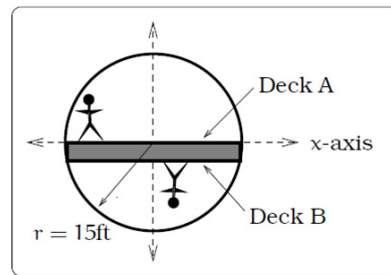
(a) Cross-section of tunnel.
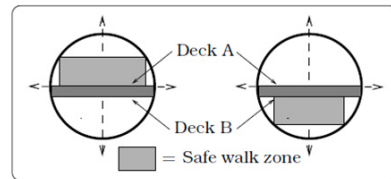
(b) Walk zones.

20. A crawling tractor sprinkler is located as pictured here, 100 feet South of a sidewalk. Once the water is turned on, the sprinkler waters a circular disc of radius 20 feet and moves North along the hose at the rate of ½ inch/second. The hose is perpendicular to the 10 ft. wide sidewalk. Assume there is grass on both sides of the sidewalk. [UW]
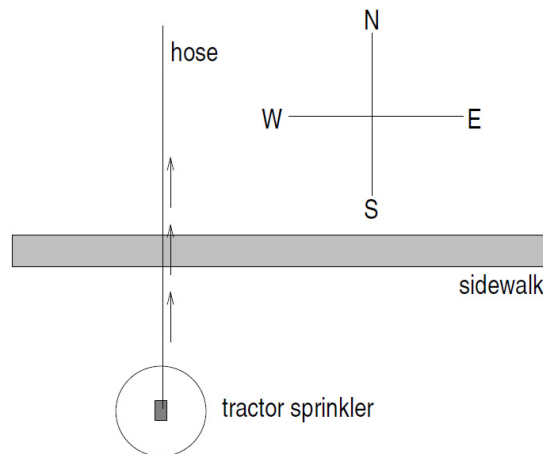
a) Impose a coordinate system. Describe the initial coordinates of the sprinkler and find equations of the lines forming and find equations of the lines forming the North and South boundaries of the sidewalk.
b) When will the water first strike the sidewalks?
c) When will the water from the sprinkler fall completely North of the sidewalk?
d) Find the total amount of time water from the sprinkler falls on the sidewalk.
e) Sketch a picture of the situation after 33 minutes. Draw an accurate picture of the watered portion of the sidewalk.
f) Find the areas of GRASS watered after one hour.

21. Erik's disabled sailboat is floating stationary 3 miles East and 2 miles North of Kingston. A ferry leaves Kingston heading toward Edmonds at 12 mph. Edmonds is 6 miles due east of Kingston. After 20 minutes the ferry turns heading due South. Ballard is 8 miles South and 1 mile West of Edmonds. Impose coordinates with Ballard as the origin. [UW]
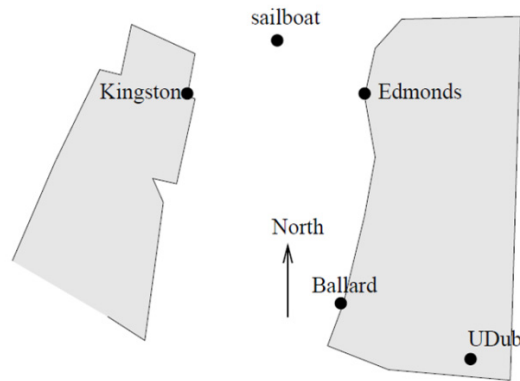
a) Find the equations for the lines along which the ferry is moving and draw in these lines.
b) The sailboat has a radar scope that will detect any object within 3 miles of the sailboat. Looking down from above, as in the picture, the radar region looks like a circular disk. The boundary is the "edge" pr circle around this disc, the interior is the inside of the disk, and the exterior is everything outside of the disk (i.e. outside of the circle). Give the mathematical (equation) description of the boundary, interior and exterior of the radar zone. Sketch an accurate picture of the radar zone. Sketch an accurate picture of the radar zone by determining where the line connecting Kingston and Edmonds would cross the radar zone.
c) When does the ferry exit the radar zone?
d) Where and when does the ferry exit the radar zone?
e) How long does the ferry spend inside the radar zone?

22. Nora spends part of her summer driving a combine during the wheat harvest. Assume she starts at the indicated position heading east at 10 ft/sec toward a circular wheat field or radius 200 ft. The combine cuts a swath 20 feet wide and beings when the corner of the machine labeled "a" is 60 feet north and 60 feet west of the western-most edge of the field. [UW]
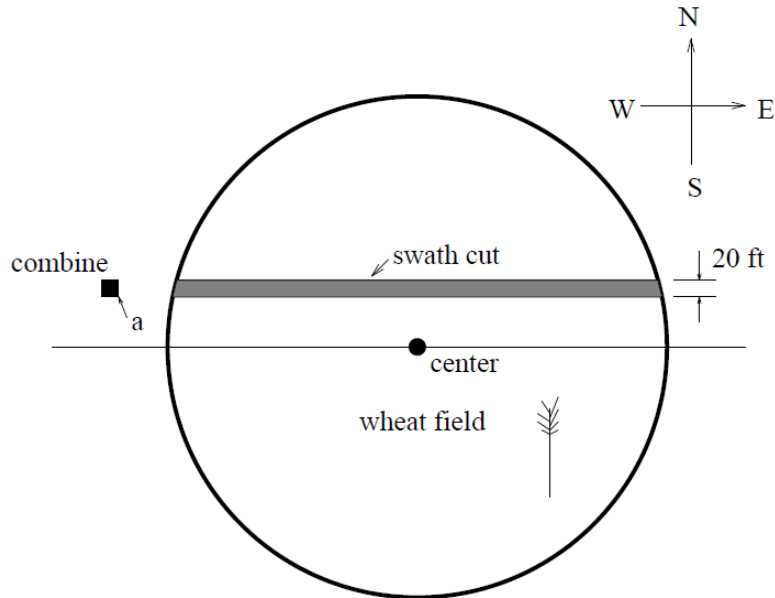
a) When does Nora's rig first start cutting the wheat?
b) When does Nora's first start cutting a swath 20 feet wide?
c) Find the total amount of time wheat is being cut during this pass across the field?
d) Estimate the area of the swath cut during this pass across the field?

23. The vertical cross-section of a drainage ditch is pictured below. Here, R indicates a circle of radius 10 feet and all of the indicated circle centers lie along the common horizontal line 10 feet above and parallel to the ditch bottom. Assume that water is flowing into the ditch so that the level above the bottom is rising 2 inches per minute. [UW]

3D–view of ditch

vertical cross-section
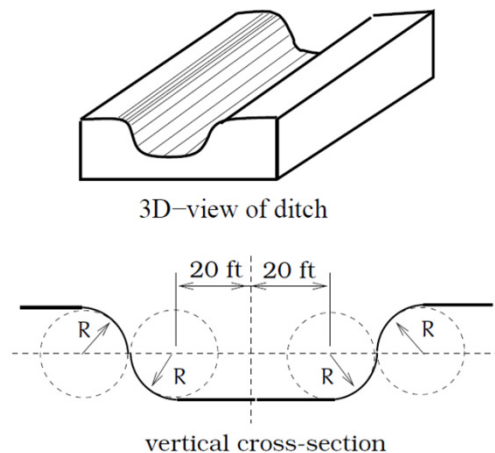
a) When will the ditch be completely full?
b) Find a multipart function that models the vertical cross-section of the ditch.
c) What is the width of the filled portion of the ditch after 1 hour and 18 minutes?
d) When will the filled portion of the ditch be 42 feet wide? 50 feet wide? 73 feet wide?

Section 5.2 Exercises

1. Indicate each angle on a circle: 30°, 300°, -135°, 70°, $\dfrac{2\pi}{3}$, $\dfrac{7\pi}{4}$

2. Indicate each angle on a circle: 30°, 315°, -135°, 80°, $\dfrac{7\pi}{6}$, $\dfrac{3\pi}{4}$

3. Convert the angle 180° to radians.

4. Convert the angle 30° to radians.

5. Convert the angle $\dfrac{5\pi}{6}$ from radians to degrees.

6. Convert the angle $\dfrac{11\pi}{6}$ from radians to degrees.

7. Find the angle between 0° and 360° that is coterminal with a 685° angle

8. Find the angle between 0° and 360° that is coterminal with a 451° angle

9. Find the angle between 0° and 360° that is coterminal with a -1746° angle

10. Find the angle between 0° and 360° that is coterminal with a -1400° angle

11. The angle between 0 and 2π in radians that is coterminal with the angle $\dfrac{26\pi}{9}$

12. The angle between 0 and 2π in radians that is coterminal with the angle $\dfrac{17\pi}{3}$

13. The angle between 0 and 2π in radians that is coterminal with the angle $-\dfrac{3\pi}{2}$

14. The angle between 0 and 2π in radians that is coterminal with the angle $-\dfrac{7\pi}{6}$

15. In a circle of radius 7 miles, find the length of the arc that subtends a central angle of 5 radians.

16. In a circle of radius 6 feet, find the length of the arc that subtends a central angle of 1 radian.

17. In a circle of radius 12 cm, find the length of the arc that subtends a central angle of 120 degrees.

18. In a circle of radius 9 miles, find the length of the arc that subtends a central angle of 800 degrees.

19. Find the distance along an arc on the surface of the earth that subtends a central angle of 5 minutes (1 minute = 1/60 degree). The radius of the earth is 3960 miles.

20. Find the distance along an arc on the surface of the earth that subtends a central angle of 7 minutes (1 minute = 1/60 degree). The radius of the earth is 3960 miles.

21. On a circle of radius 6 feet, what angle in degrees would subtend an arc of length 3 feet?

22. On a circle of radius 5 feet, what angle in degrees would subtend an arc of length 2 feet?

23. A sector of a circle has a central angle of 45°. Find the area of the sector if the radius of the circle is 6 cm.

24. A sector of a circle has a central angle of 30°. Find the area of the sector if the radius of the circle is 20 cm.

25. A truck with 32-in.-diameter wheels is traveling at 60 mi/h. Find the angular speed of the wheels in rad/min. How many revolutions per minute do the wheels make?

26. A bicycle with 24-in.-diameter wheels is traveling at 15 mi/h. Find the angular speed of the wheels in rad/min. How many revolutions per minute do the wheels make?

27. A wheel of radius 8 in. is rotating 15°/sec. What is the linear speed v, the angular speed in RPM, and the angular speed in rad/sec?

28. A wheel of radius 14 in. is rotating 0.5 rad/sec. What is the linear speed v, the angular speed in RPM, and the angular speed in deg/sec?

29. A CD has diameter of 120 millimeters. The angular speed varies to keep the linear speed constant where the disc is being read. When reading along the outer edge of the disc, the angular speed is about 200 RPM (revolutions per minute). Find the linear speed.

30. When being burned in a writable CD-ROM drive, the angular speed is often much faster than when playing audio, but the angular speed still varies to keep the linear speed constant where the disc is being written. When writing along the outer edge of the disc, the angular speed of one drive is about 4800 RPM (revolutions per minute). Find the linear speed.

31. You are standing on the equator of the earth (radius 3960 miles). What is your linear and angular speed?

32. The restaurant in the Space Needle in Seattle rotates at the rate of one revolution per hour. [UW]
    a) Through how many radians does it turn in 100 minutes?
    b) How long does it take the restaurant to rotate through 4 radians?
    c) How far does a person sitting by the window move in 100 minutes if the radius of the restaurant is 21 meters?

Section 5.3 Exercises

1. Find the quadrant in which the terminal point determined by t lies if
   a. $\sin(t) < 0$ and $\cos(t) < 0$ b. $\sin(t) > 0$ and $\cos(t) < 0$

2. Find the quadrant in which the terminal point determined by t lies if
   a. $\sin(t) < 0$ and $\cos(t) > 0$ b. $\sin(t) > 0$ and $\cos(t) > 0$

3. The point P is on the unit circle. If the y-coordinate of P is $\dfrac{3}{5}$, and P is in quadrant II, find the x coordinate.

4. The point P is on the unit circle. If the x-coordinate of P is $\dfrac{1}{5}$, and P is in quadrant IV, find the y coordinate.

5. If $\cos(\theta) = \dfrac{1}{7}$ and θ is in the 4th quadrant, find $\sin(\theta)$

6. If $\cos(\theta) = \dfrac{2}{9}$ and θ is in the 1st quadrant, find $\sin(\theta)$

7. If $\sin(\theta) = \dfrac{3}{8}$ and θ is in the 2nd quadrant, find $\cos(\theta)$

8. If $\sin(\theta) = -\dfrac{1}{4}$ and θ is in the 3rd quadrant, find $\cos(\theta)$

9. For each of the following angles, find the reference angle, and what quadrant the angle lies in. Then compute sine and cosine of the angle.
   a. 225°   b. 300°   c. 135°   d. 210°

10. For each of the following angles, find the reference angle, and what quadrant the angle lies in. Then compute sine and cosine of the angle.
    a. 120°   b. 315°   c. 250°   d. 150°

11. For each of the following angles, find the reference angle, and what quadrant the angle lies in. Then compute sine and cosine of the angle.
    a. $\dfrac{5\pi}{4}$ b. $\dfrac{7\pi}{6}$ c. $\dfrac{5\pi}{3}$ d. $\dfrac{3\pi}{4}$

12. For each of the following angles, find the reference angle, and what quadrant the angle lies in. Then compute sine and cosine of the angle.
    a. $\dfrac{4\pi}{3}$ b. $\dfrac{2\pi}{3}$ c. $\dfrac{5\pi}{6}$ d. $\dfrac{7\pi}{4}$

13. Give exact values for $\sin(\theta)$ and $\cos(\theta)$ for each of these angles.

    a. $-\dfrac{3\pi}{4}$ b. $\dfrac{23\pi}{6}$ c. $-\dfrac{\pi}{2}$ d. 5π

14. Give exact values for $\sin(\theta)$ and $\cos(\theta)$ for each of these angles.

    a. $-\dfrac{2\pi}{3}$ b. $\dfrac{17\pi}{4}$ c. $-\dfrac{\pi}{6}$ d. 10π

15. Find an angle theta with $0 < \theta < 360°$ or $0 < \theta < 2\pi$ that has the same sine value as:

    a. $\dfrac{\pi}{3}$ b. $80°$ c. $140°$ d. $\dfrac{4\pi}{3}$ e. $305°$

16. Find an angle theta with $0 < \theta < 360°$ or $0 < \theta < 2\pi$ that has the same sine value as:

    a. $\dfrac{\pi}{4}$ b. $15°$ c. $160°$ d. $\dfrac{7\pi}{6}$ e. $340°$

17. Find an angle theta with $0 < \theta < 360°$ or $0 < \theta < 2\pi$ that has the same cosine value as:

    a. $\dfrac{\pi}{3}$ b. $80°$ c. $140°$ d. $\dfrac{4\pi}{3}$ e. $305°$

18. Find an angle theta with $0 < \theta < 360°$ or $0 < \theta < 2\pi$ that has the same cosine value as:

    a. $\dfrac{\pi}{4}$ b. $15°$ c. $160°$ d. $\dfrac{7\pi}{6}$ e. $340°$

19. Find the coordinates of a point on a circle with radius 15 corresponding to an angle of $220°$

20. Find the coordinates of a point on a circle with radius 20 corresponding to an angle of $280°$

21. Marla is running clockwise around a circular track. She runs at a constant speed of 3 meters per second. She takes 46 seconds to complete one lap of the track. From her starting point, it takes her 12 seconds to reach the northernmost point of the track. Impose a coordinate system with the center of the track at the origin, and the northernmost point on the positive y-axis. [UW]

    a) Give Marla's coordinates at her starting point.
    b) Give Marla's coordinates when she has been running for 10 seconds.
    c) Give Marla's coordinates when she has been running for 901.3 seconds.

Section 5.4 Exercises

1. If $\theta = \dfrac{\pi}{4}$, then find exact values for $\sec(\theta), \csc(\theta), \tan(\theta), \cot(\theta)$

2. If $\theta = \dfrac{7\pi}{4}$, then find exact values for $\sec(\theta), \csc(\theta), \tan(\theta), \cot(\theta)$

3. If $\theta = \dfrac{5\pi}{6}$, then find exact values for $\sec(\theta), \csc(\theta), \tan(\theta), \cot(\theta)$

4. If $\theta = \dfrac{\pi}{6}$, then find exact values for $\sec(\theta), \csc(\theta), \tan(\theta), \cot(\theta)$

5. If $\theta = \dfrac{2\pi}{3}$, then find exact values for $\sec(\theta), \csc(\theta), \tan(\theta), \cot(\theta)$

6. If $\theta = \dfrac{4\pi}{3}$, then find exact values for $\sec(\theta), \csc(\theta), \tan(\theta), \cot(\theta)$

7. Evaluate: a. $\sec(135°)$ b. $\csc(210°)$ c. $\tan(60°)$ d. $\cot(225°)$

8. Evaluate: a. $\sec(30°)$ b. $\csc(315°)$ c. $\tan(135°)$ d. $\cot(150°)$

9. If $\sin(\theta) = \dfrac{3}{4}$, and θ is in quadrant II, then find
   $\cos(\theta), \sec(\theta), \csc(\theta), \tan(\theta), \cot(\theta)$

10. If $\sin(\theta) = \dfrac{2}{7}$, and θ is in quadrant II, then find
    $\cos(\theta), \sec(\theta), \csc(\theta), \tan(\theta), \cot(\theta)$

11. If $\cos(\theta) = -\dfrac{1}{3}$, and θ is in quadrant III, then find
    $\sin(\theta), \sec(\theta), \csc(\theta), \tan(\theta), \cot(\theta)$

12. If $\cos(\theta) = \dfrac{1}{5}$, and θ is in quadrant I, then find
    $\sin(\theta), \sec(\theta), \csc(\theta), \tan(\theta), \cot(\theta)$

13. If $\tan(\theta) = \dfrac{12}{5}$, and $0 \le \theta < \dfrac{\pi}{2}$, then find $\sin(\theta), \cos(\theta), \sec(\theta), \csc(\theta), \cot(\theta)$

14. If $\tan(\theta) = 4$, and $0 \le \theta < \dfrac{\pi}{2}$, then find $\sin(\theta), \cos(\theta), \sec(\theta), \csc(\theta), \cot(\theta)$

15. Use a calculator to find sine, cosine, and tangent of the following values:

    a. 0.15　　　　　b. 4　　　　　c. 70°　　　　d. 283°

16. Use a calculator to find sine, cosine, and tangent of the following values:

    a. 0.5　　　　　b. 5.2　　　　c. 10°　　　　d. 195°

Simplify each of the following to an expression involving a single trig function with no fractions.

17. $\csc(t)\tan(t)$

18. $\cos(t)\csc(t)$

19. $\dfrac{\sec(t)}{\csc(t)}$

20. $\dfrac{\cot(t)}{\csc(t)}$

21. $\dfrac{\sec(t)-\cos(t)}{\sin(t)}$

22. $\dfrac{\tan(t)}{\sec(t)-\cos(t)}$

23. $\dfrac{1+\cot(t)}{1+\tan(t)}$

24. $\dfrac{1+\sin(t)}{1+\csc(t)}$

25. $\dfrac{\sin^{2}(t)+\cos^{2}(t)}{\cos^{2}(t)}$

26. $\dfrac{1-\sin^{2}(t)}{\sin^{2}(t)}$

Prove the identities

27. $\dfrac{\sin^2(\theta)}{1+\cos(\theta)} = 1 - \cos(\theta)$

28. $\tan^2(t) = \dfrac{1}{\cos^2(t)} - 1$

29. $\sec(a) - \cos(a) = \sin(a)\tan(a)$

30. $\dfrac{1+\tan^2(b)}{\tan^2(b)} = \csc^2(b)$

31. $\dfrac{\csc^2(x) - \sin^2(x)}{\csc(x) + \sin(x)} = \cos(x)\cot(x)$

32. $\dfrac{\sin(\theta) - \cos(\theta)}{\sec(\theta) - \csc(\theta)} = \sin(\theta)\cos(\theta)$

33. $\dfrac{\csc^2(\alpha) - 1}{\csc^2(\alpha) - \csc(\alpha)} = 1 + \sin(\alpha)$

34. $1 + \cot(x) = \cos(x)\big(\sec(x) + \csc(x)\big)$

35. $\dfrac{1+\cos(u)}{\sin(u)} = \dfrac{\sin(u)}{1 - \cos(u)}$

36. $2\sec^2(t) = \dfrac{1 - \sin(t)}{\cos^2(t)} + \dfrac{1}{1 - \sin(t)}$

37. $\dfrac{\sin^4(\gamma) - \cos^4(\gamma)}{\sin(\gamma) - \cos(\gamma)} = \sin(\gamma) + \cos(\gamma)$

38. $\dfrac{\big(1+\cos(A)\big)\big(1-\cos(A)\big)}{\sin(A)} = \sin(A)$

Section 5.5 Exercises

Note: pictures may not be drawn to scale.

In each of the triangles below, find $\sin(A), \cos(A), \tan(A), \sec(A), \csc(A), \cot(A)$
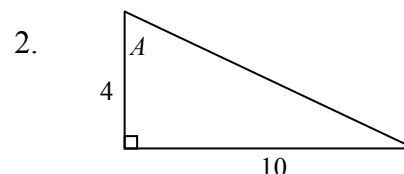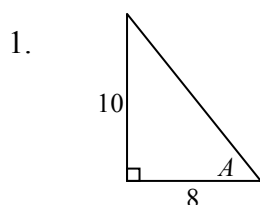
1.

10

8

A

2.

A

4

10

In each of the following triangles, solve for the unknown sides and angles.

3.

B

7

c

b

30°

4.

10

A

a

c

60°

5.

10

A

a

c

62°

6.

B

7

c

b

35°

7.

a

B

b

10

65°

8.

B

a

12

b

10°
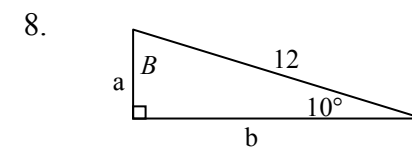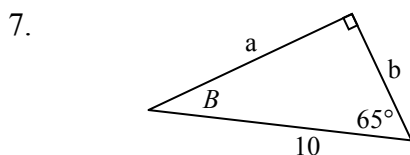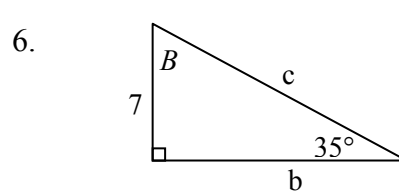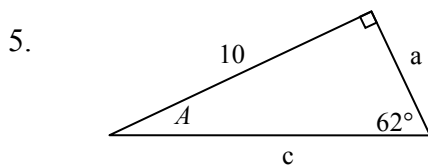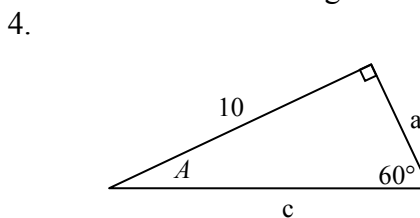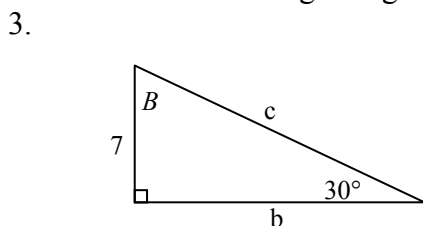
9. A 33-ft ladder leans against a building so that the angle between the ground and the ladder is 80°. How high does the ladder reach on the building?

10. A 23-ft ladder leans against a building so that the angle between the ground and the ladder is 80°. How high does the ladder reach on the building?

11. The angle of elevation to the top of a building in New York is found to be 9 degrees from the ground at a distance of 1 mile from the base of the building. Using this information, find the height of the building.

12. The angle of elevation to the top of a building in Seattle is found to be 2 degrees from the ground at a distance of 2 miles from the base of the building. Using this information, find the height of the building.

13. A radio tower is located 400 feet from a building. From a window in the building, a person determines that the angle of elevation to the top of the tower is 36° and that the angle of depression to the bottom of the tower is 23°. How tall is the tower?

14. A radio tower is located 325 feet from a building. From a window in the building, a person determines that the angle of elevation to the top of the tower is 43° and that the angle of depression to the bottom of the tower is 31°. How tall is the tower?

15. A 200 foot tall monument is located in the distance. From a window in a building, a person determines that the angle of elevation to the top of the monument is 15° and that the angle of depression to the bottom of the tower is 2°. How far is the person from the monument?

16. A 400 foot tall monument is located in the distance. From a window in a building, a person determines that the angle of elevation to the top of the monument is 18° and that the angle of depression to the bottom of the tower is 3°. How far is the person from the monument?

17. There is an antenna on the top of a building. From a location 300 feet from the base of the building, the angle of elevation to the top of the building is measured to be 40°. From the same location, the angle of elevation to the top of the antenna is measured to be 43°. Find the height of the antenna.

18. There is lightning rod on the top of a building. From a location 500 feet from the base of the building, the angle of elevation to the top of the building is measured to be 36°. From the same location, the angle of elevation to the top of the lightning rod is measured to be 38°. Find the height of the lightning rod.

19. Find the length x
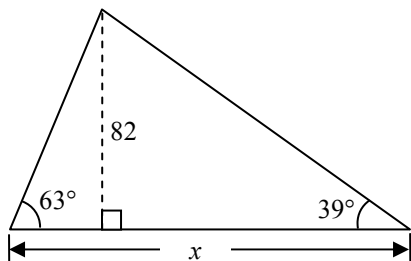
20. Find the length x
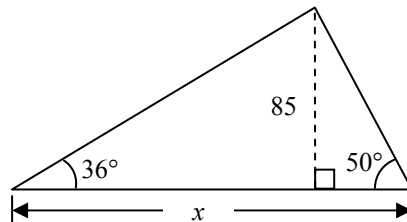
21. Find the length x

115

56°   35°

x
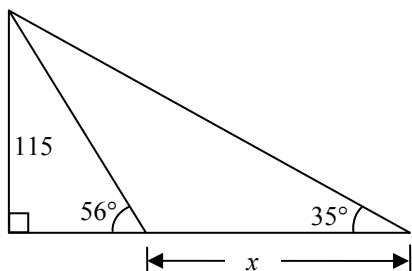
22. Find the length x

119

70°   26°

x
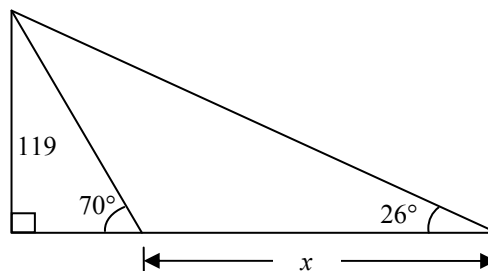
23. A plane is flying 2000 feet above sea level toward a mountain. The pilot observes the top of the mountain to be 18° above the horizontal, then immediately flies the plane at an angle of 20° above horizontal. The airspeed of the plane is 100 mph. After 5 minutes, the plane is directly above the top of the mountain. How high is the plane above the top of the mountain (when it passes over)? What is the height of the mountain? [UW]

T

E

P

2000 ft

L

S sealevel
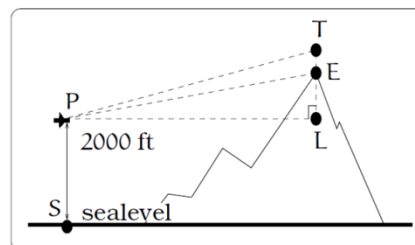
24. Three airplanes depart SeaTac Airport. A NorthWest flight is heading in a direction 50° counterclockwise from East, an Alaska flight is heading 115° counterclockwise from East and a Delta flight is heading 20° clockwise from East. Find the location of the Northwest flight when it is 20 miles North of SeaTac. Find the location of the Alaska flight when it is 50 miles West of SeaTac. Find the location of the Delta flight when it is 30 miles East of SeaTac. [UW]

North

Alaska   Northwest

50°

115°

West   East

SeaTac   20°

South   Delta
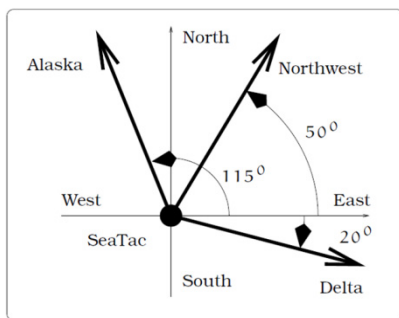
(a) The flight paths of three airplanes.

Alaska $x = 30$

Q   Northwest

N

P $y = 20$

W   E

R   Delta

$x = -50$

S
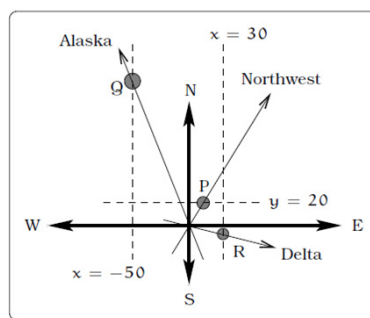
(b) Modeling the paths of each flight.

25. The crew of a helicopter needs to land temporarily in a forest and spot a flat horizontal piece of ground (a clearing in the forest) as a potential landing site, but are uncertain whether it is wide enough. They make two measurements from A (see picture) finding $\alpha = 25°$ and $\beta = 54°$. They rise vertically 100 feet to B and measure $\gamma = 47°$. Determine the width of the clearing to the nearest foot. [UW]
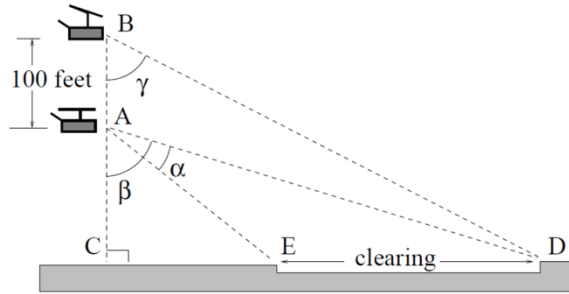
26. A Forest Service helicopter needs to determine the width of a deep canyon. While hovering, they measure the angle $\gamma = 48°$ at position B (see picture), then descend 400 feet to position A and make two measurements of $\alpha = 13°$ (the measure of $\angle EAD$), $\beta = 53°$ (the measure of $\angle CAD$). Determine the width of the canyon to the nearest foot. [UW]
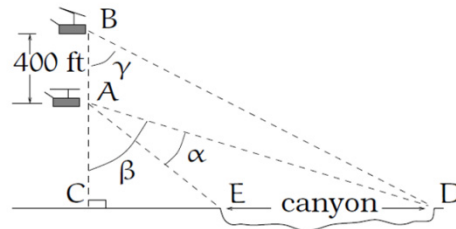
Section 6.1 Exercises

1. Sketch a graph of $f(x) = -3\sin(x)$

2. Sketch a graph of $f(x) = 4\sin(x)$

3. Sketch a graph of $f(x) = 2\cos(x)$

4. Sketch a graph of $f(x) = -4\cos(x)$

For the graphs below, determine the amplitude, midline, and period, then write an equation for the graph.

5.
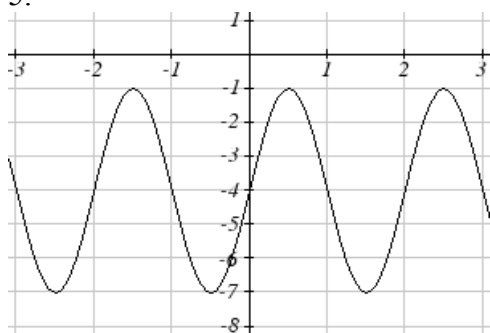
6.
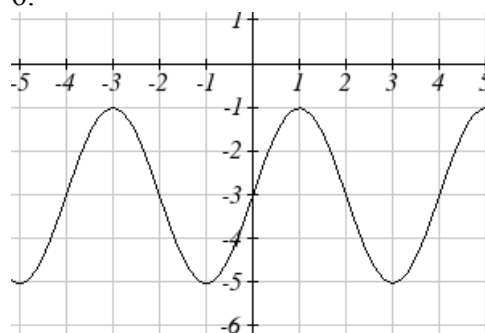
7.
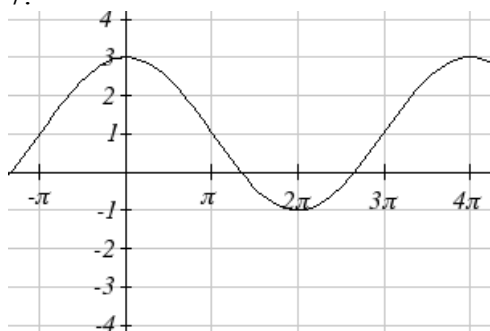
8.
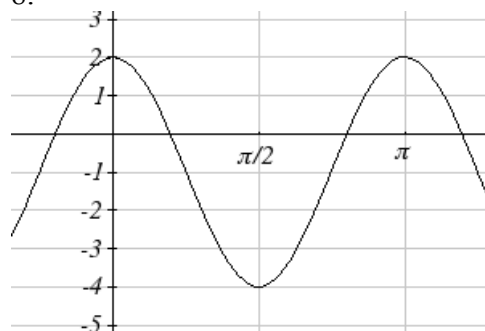
9.

10.
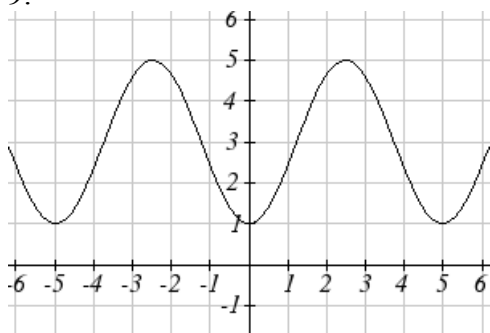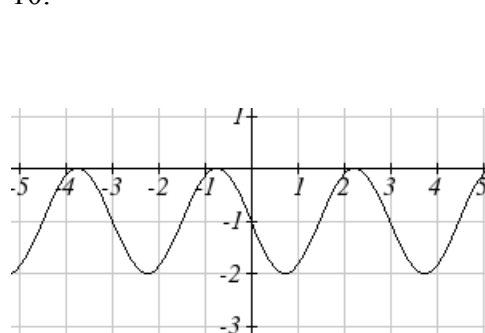
For each of the following equations, find the amplitude, period, horizontal shift, and midline.

11. $y = 3\sin(8(x+4)) + 5$

12. $y = 4\sin\left(\frac{\pi}{2}(x-3)\right) + 7$

13. $y = 2\sin(3x - 21) + 4$

14. $y = 5\sin(5x + 20) - 2$

15. $y = \sin\left(\frac{\pi}{6}x + \pi\right) - 3$

16. $y = 8\sin\left(\frac{7\pi}{6}x + \frac{7\pi}{2}\right) + 6$

Find a formula for each of the graphs shown below.

17.

18.

19.

20.
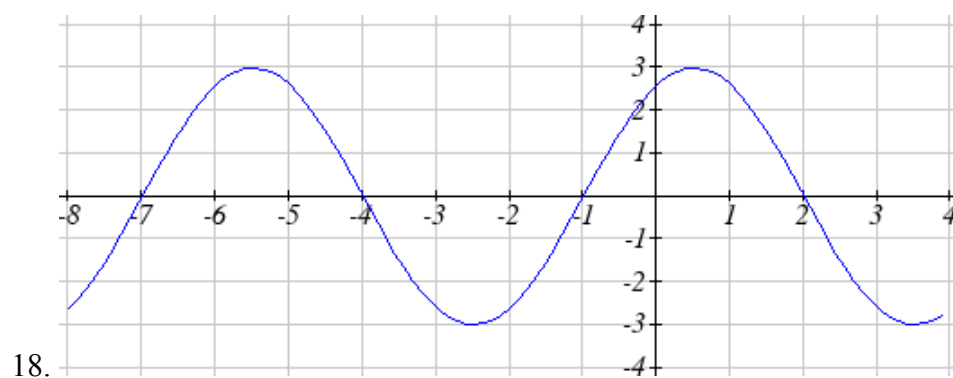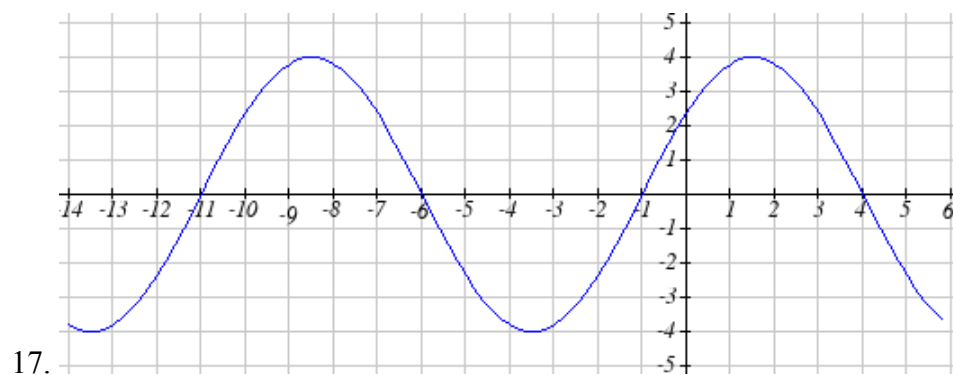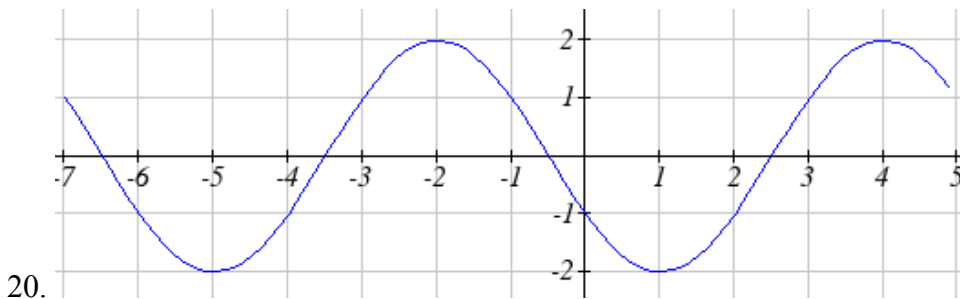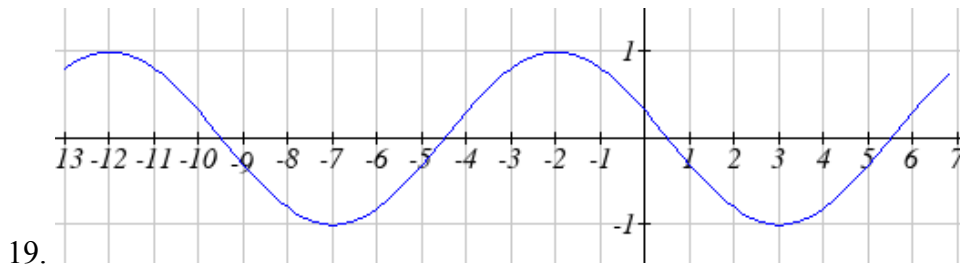
21. Outside temperature over a day can be modeled as a sinusoidal function. Suppose you know the temperature is 50 degrees at midnight and the high and low temperature during the day are 57 and 43 degrees, respectively. Assuming t is the number of hours since midnight, find an equation for the temperature, D, in terms of t.

22. Outside temperature over a day can be modeled as a sinusoidal function. Suppose you know the temperature is 68 degrees at midnight and the high and low temperature during the day are 80 and 56 degrees, respectively. Assuming t is the number of hours since midnight, find an equation for the temperature, D, in terms of t.

23. A Ferris wheel is 25 meters in diameter and boarded from a platform that is 1 meters above the ground. The six o'clock position on the Ferris wheel is level with the loading platform. The wheel completes 1 full revolution in 10 minutes. The function $h(t)$ gives your height in meters above the ground t minutes after the wheel begins to turn.

    a. Find the amplitude, midline, and period of $h(t)$

    b. Find an equation for the height function $h(t)$

    c. How high are you off the ground after 5 minutes?

24. A Ferris wheel is 35 meters in diameter and boarded from a platform that is 3 meters above the ground. The six o'clock position on the Ferris wheel is level with the loading platform. The wheel completes 1 full revolution in 8 minutes. The function $h(t)$ gives your height in meters above the ground t minutes after the wheel begins to turn.

    a. Find the amplitude, midline, and period of $h(t)$

    b. Find an equation for the height function $h(t)$

    c. How high are you off the ground after 4 minutes?

Section 6.2 Exercises

Match the trigonometric function with one of the graphs

1. $f(x) = \tan(x)$
2. $f(x) = \sec(x)$

3. $f(x) = \csc(x)$
4. $f(x) = \cot(x)$

I

II

III

IV
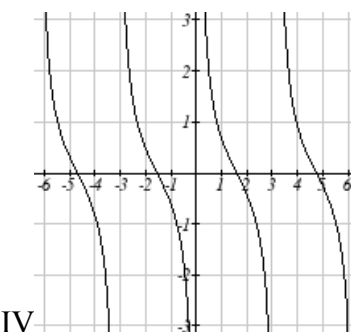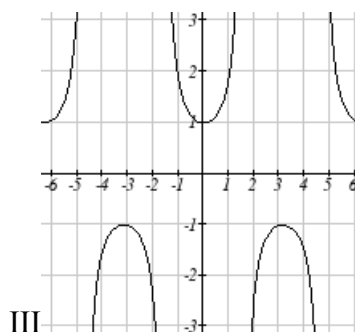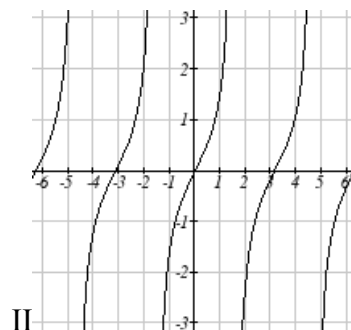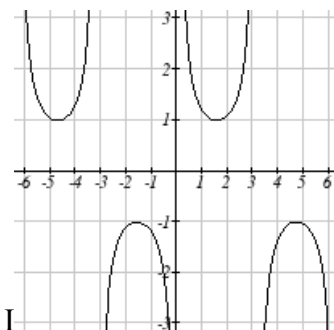
Find the period and horizontal shift of each of the following functions.

5. $f(x) = 2\tan(4x - 32)$

6. $g(x) = 3\tan(6x + 42)$

7. $h(x) = 2\sec\left(\dfrac{\pi}{4}(x+1)\right)$

8. $k(x) = 3\sec\left(2\left(x + \dfrac{\pi}{2}\right)\right)$

9. $m(x) = 6\csc\left(\dfrac{\pi}{3}x + \pi\right)$

10. $n(x) = 4\csc\left(\dfrac{5\pi}{3}x - \dfrac{20\pi}{3}\right)$

11. Sketch a graph of #7 above
12. Sketch a graph of #8 above
13. Sketch a graph of #9 above
14. Sketch a graph of #10 above

15. Sketch a graph of $j(x) = \tan\left(\dfrac{\pi}{2}x\right)$

16. Sketch a graph of $p(t) = 2\tan\left(t - \dfrac{\pi}{2}\right)$

Write an equation for each of the graphs shown

17.

18.

19.

20.
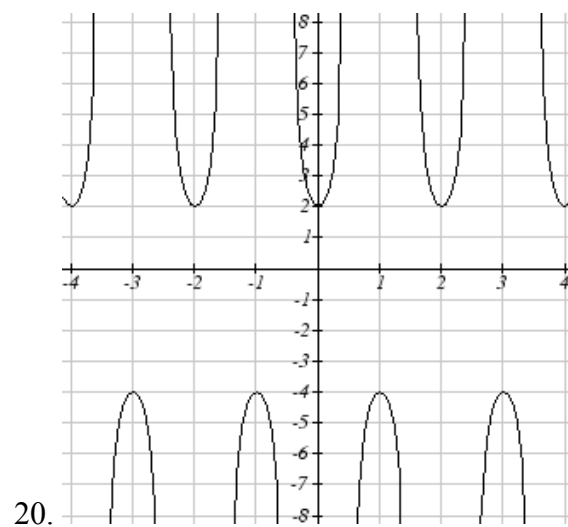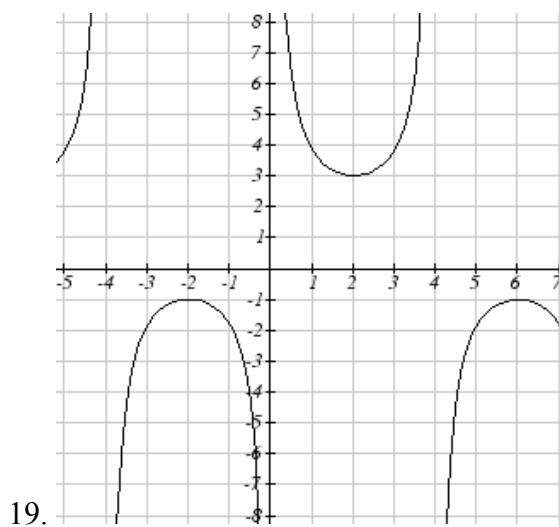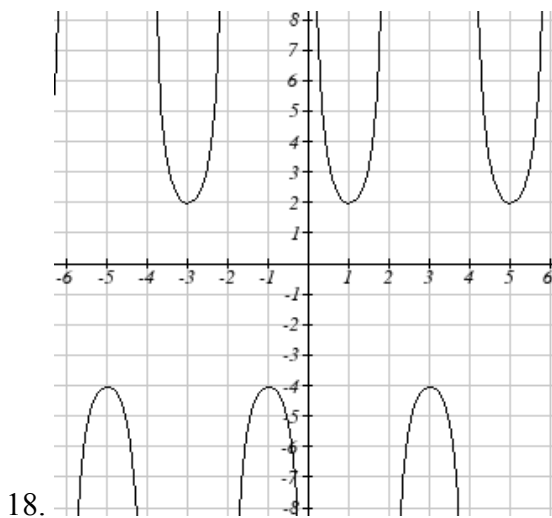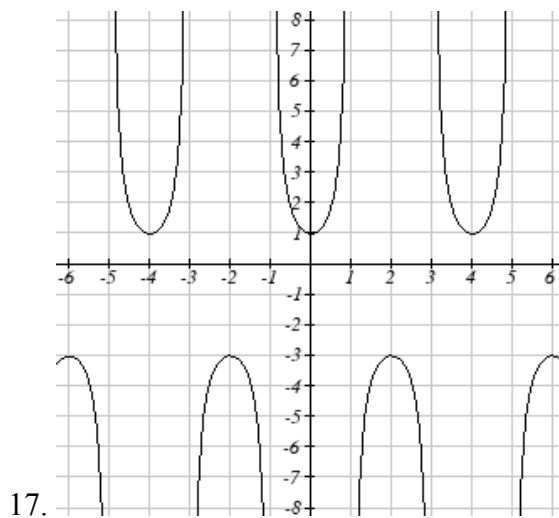
21. If $\tan x = -1.5$, find $\tan(-x)$

22. If $\tan x = 3$, find $\tan(-x)$

23. If $\sec x = 2$, find $\sec(-x)$

24. If $\sec x = -4$, find $\sec(-x)$

25. If $\csc x = -5$, find $\csc(-x)$

26. If $\csc x = 2$, find $\csc(-x)$

Simplify each of the following expressions completely

27. $\cot(-x)\cos(-x) + \sin(-x)$

28. $\cos(-x) + \tan(-x)\sin(-x)$

Section 6.3 Exercises

Evaluate the following expressions

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

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

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

4. $\sin^{-1}\left(-\dfrac{\sqrt{2}}{2}\right)$

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

6. $\cos^{-1}\left(\dfrac{\sqrt{2}}{2}\right)$

7. $\cos^{-1}\left(-\dfrac{\sqrt{2}}{2}\right)$

8. $\cos^{-1}\left(-\dfrac{\sqrt{3}}{2}\right)$

9. $\tan^{-1}(1)$

10. $\tan^{-1}\left(\sqrt{3}\right)$

11. $\tan^{-1}\left(-\sqrt{3}\right)$

12. $\tan^{-1}(-1)$

Use your calculator to evaluate each expression

13. $\cos^{-1}(-0.4)$

14. $\cos^{-1}(0.8)$

15. $\sin^{-1}(-0.8)$

16. $\tan^{-1}(6)$

Solve the triangle for the angle
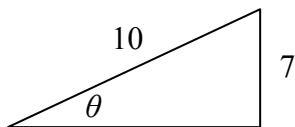
17.
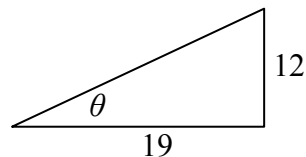
18.

Evaluate the following expressions

19. $\sin^{-1}\left(\cos\left(\dfrac{\pi}{4}\right)\right)$

20. $\cos^{-1}\left(\sin\left(\dfrac{\pi}{6}\right)\right)$

21. $\sin^{-1}\left(\cos\left(\dfrac{4\pi}{3}\right)\right)$

22. $\cos^{-1}\left(\sin\left(\dfrac{5\pi}{4}\right)\right)$

23. $\cos\left(\sin^{-1}\left(\dfrac{3}{7}\right)\right)$

24. $\sin\left(\cos^{-1}\left(\dfrac{4}{9}\right)\right)$

25. $\cos\left(\tan^{-1}(4)\right)$

26. $\tan\left(\sin^{-1}\left(\dfrac{1}{3}\right)\right)$

Find a simplified expression for each of the following

27. $\sin\left(\cos^{-1}\left(\dfrac{x}{5}\right)\right)$, for $-5 \le x \le 5$

28. $\tan\left(\cos^{-1}\left(\dfrac{x}{2}\right)\right)$, for $-2 \le x \le 2$

29. $\sin\left(\tan^{-1}(3x)\right)$

30. $\cos\left(\tan^{-1}(4x)\right)$

Section 6.4 Exercises

Find all solutions on the interval $0 \le \theta < 2\pi$

1. $2\sin(\theta) = -\sqrt{2}$ 2. $2\sin(\theta) = \sqrt{3}$ 3. $2\cos(\theta) = 1$ 4. $2\cos(\theta) = -\sqrt{2}$

5. $\sin(\theta) = 1$ 6. $\sin(\theta) = 0$ 7. $\cos(\theta) = 0$ 8. $\cos(\theta) = -1$

Find all solutions

9. $2\cos(\theta) = \sqrt{2}$ 10. $2\cos(\theta) = -1$ 11. $2\sin(\theta) = -1$ 12. $2\sin(\theta) = -\sqrt{3}$

Find all solutions

13. $2\sin(3\theta) = 1$ 14. $2\sin(2\theta) = \sqrt{3}$ 15. $2\sin(3\theta) = -\sqrt{2}$

16. $2\sin(3\theta) = -1$ 17. $2\cos(2\theta) = 1$ 18. $2\cos(2\theta) = \sqrt{3}$

19. $2\cos(3\theta) = -\sqrt{2}$ 20. $2\cos(2\theta) = -1$ 21. $\cos\left(\dfrac{\pi}{4}\theta\right) = -1$

22. $\sin\left(\dfrac{\pi}{3}\theta\right) = -1$ 23. $2\sin(\pi\theta) = 1$.   24. $2\cos\left(\dfrac{\pi}{5}\theta\right) = \sqrt{3}$

Find all solutions on the interval $0 \le x < 2\pi$

25. $\sin(x) = 0.27$ 26. $\sin(x) = 0.48$ 27. $\sin(x) = -0.58$ 28. $\sin(x) = -0.34$

29. $\cos(x) = -0.55$ 30. $\sin(x) = 0.28$ 31. $\cos(x) = 0.71$ 32. $\cos(x) = -0.07$

Find the first two positive solutions

33. $7\sin(6x) = 2$ 34. $7\sin(5x) = 6$ 35. $5\cos(3x) = -3$ 36. $3\cos(4x) = 2$

37. $3\sin\left(\dfrac{\pi}{4}x\right) = 2$ 38. $7\sin\left(\dfrac{\pi}{5}x\right) = 6$ 39. $5\cos\left(\dfrac{\pi}{3}x\right) = 1$ 40. $3\cos\left(\dfrac{\pi}{2}x\right) = -2$

Section 6.5 Exercises

In each of the following triangles, solve for the unknown side and angles.
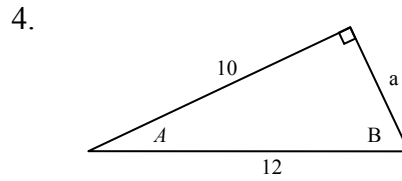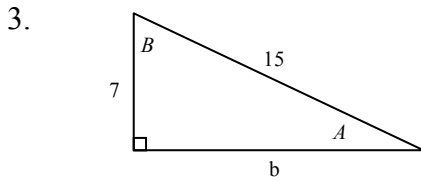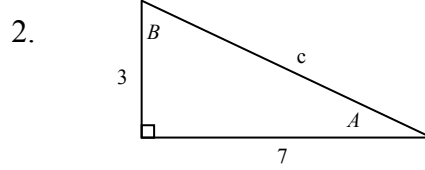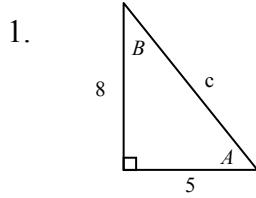
1.

2.

3.

4.

Find a possible formula for the trigonometric function whose values are in the following tables.

5.

x	0	1	2	3	4	5	6
y	-2	4	10	4	-2	4	10

6.

x	0	1	2	3	4	5	6
y	1	-3	-7	-3	1	-3	-7

7. Outside temperature over a day can be modeled as a sinusoidal function. Suppose you know the high temperature for the day is 63 degrees and the low temperature of 37 degrees occurs at 5 AM. Assuming t is the number of hours since midnight, find an equation for the temperature, D, in terms of t.

8. Outside temperature over a day can be modeled as a sinusoidal function. Suppose you know the high temperature for the day is 92 degrees and the low temperature of 78 degrees occurs at 4 AM. Assuming t is the number of hours since midnight, find an equation for the temperature, D, in terms of t.

9. A population of rabbits oscillates 25 above and below an average of 129 during the year, hitting the lowest value in January ($t = 0$).
    a. Find an equation for the population, P, in terms of the months since January, t.
    b. What if the lowest value of the rabbit population occurred in April instead?

10. A population of elk oscillates 150 above and below an average of 720 during the year, hitting the lowest value in January ($t = 0$).
     a. Find an equation for the population, P, in terms of the months since January, t.
     b. What if the lowest value of the rabbit population occurred in March instead?

11. Outside temperature over a day can be modeled as a sinusoidal function. Suppose you know the high temperature of 105 degrees occurs at 5 PM and the average temperature for the day is 85 degrees. Find the temperature, to the nearest degree, at 9 AM.

12. Outside temperature over a day can be modeled as a sinusoidal function. Suppose you know the high temperature of 84 degrees occurs at 6 PM and the average temperature for the day is 70 degrees. Find the temperature, to the nearest degree, at 7 AM.

13. Outside temperature over a day can be modeled as a sinusoidal function. Suppose you know the temperature varies between 47 and 63 degrees during the day and the average daily temperature first occurs at 10 AM. How many hours after midnight does the temperature first reach 51 degrees?

14. Outside temperature over a day can be modeled as a sinusoidal function. Suppose you know the temperature varies between 64 and 86 degrees during the day and the average daily temperature first occurs at 12 AM. How many hours after midnight does the temperature first reach 70 degrees?

15. A Ferris wheel is 20 meters in diameter and boarded from a platform that is 2 meters above the ground. The six o'clock position on the Ferris wheel is level with the loading platform. The wheel completes 1 full revolution in 6 minutes. How many minutes of the ride are spent higher than 13 meters above the ground?

16. A Ferris wheel is 45 meters in diameter and boarded from a platform that is 1 meters above the ground. The six o'clock position on the Ferris wheel is level with the loading platform. The wheel completes 1 full revolution in 10 minutes. How many minutes of the ride are spent higher than 27 meters above the ground?

17. The sea ice area around the north pole fluctuates between about 6 million square kilometers in September to 14 million square kilometers in March. During how many months are there less than 9 million square kilometers of sea ice?

18. The sea ice area around the south pole fluctuates between about 18 million square kilometers in September to 3 million square kilometers in March. During how many months are there more than 15 million square kilometers of sea ice?

19. A respiratory ailment called "Cheyne-Stokes Respiration" causes the volume per breath to increase and decrease in a sinusoidal manner, as a function of time. For one particular patient with this condition, a machine begins recording a plot of volume per breath versus time (in seconds). Let $b(t)$ be a function of time t that tells us the volume (in liters) of a breath that starts at time t. During the test, the smallest volume per breath is 0.6 liters and this first occurs for a breath that starts 5 seconds into the test. The largest volume per breath is 1.8 liters and this first occurs for a breath beginning 55 seconds into the test. [UW]

   a. Find a formula for the function $b(t)$ whose graph will model the test data for this patient.

   b. If the patient begins a breath every 5 seconds, what are the breath volumes during the first minute of the test?

20. Suppose the high tide in Seattle occurs at 1:00 a.m. and 1:00 p.m. at which time the water is 10 feet above the height of low tide. Low tides occur 6 hours after high tides. Suppose there are two high tides and two low tides every day and the height of the tide varies sinusoidally. [UW]

   a. Find a formula for the function $y=h(t)$ that computes the height of the tide above low tide at time t. (In other words, $y = 0$ corresponds to low tide.)

   b. What is the tide height at 11:00 a.m.?

21. A communications satellite orbits the earth t miles above the surface. Assume the radius of the earth is 3,960 miles. The satellite can only "see" a portion of the earth's surface, bounded by what is called a horizon circle. This leads to a two-dimensional cross-sectional picture we can use to study the size of the horizon slice: [UW]
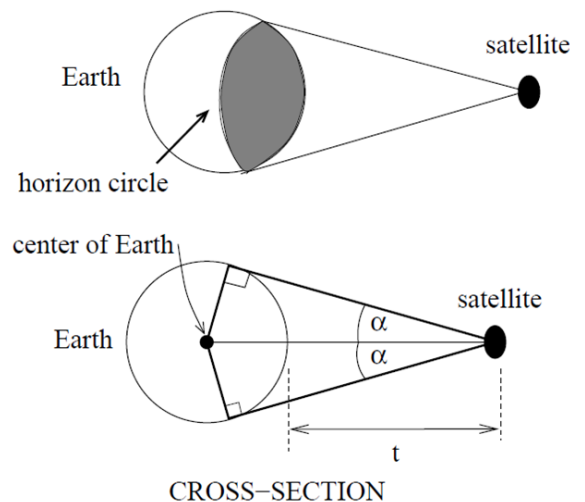
   a. Find a formula for α in terms of t.

   b. If $t = 30,000$ miles, what is α? What percentage of the circumference of the earth is covered by the satellite? What would be the minimum number of such satellites required to cover the circumference?

   c. If $t = 1,000$ miles, what is α? What percentage of the circumference of the earth is covered by the satellite? What would be the minimum number of such satellites required to cover the circumference?

   d. Suppose you wish to place a satellite into orbit so that 20% of the circumference is covered by the satellite. What is the required distance t?

22. Tiffany is a model rocket enthusiast. She has been working on a pressurized rocket filled with laughing gas. According to her design, if the atmospheric pressure exerted on the rocket is less than 10 pounds/sq.in., the laughing gas chamber inside the rocket will explode. Tiff worked from a formula $p = 14.7e^{-h/10}$ pounds/sq.in. for the atmospheric pressure h miles above sea level. Assume that the rocket is launched at an angle of α above level ground at sea level with an initial speed of 1400 feet/sec. Also, assume the height (in feet) of the rocket at time t seconds is given by the equation

$$y(t) = -16t^2 + 1400\sin(\alpha)t \quad [\text{UW}]$$

    a. At what altitude will the rocket explode?

    b. If the angle of launch is $\alpha = 12°$, determine the minimum atmospheric pressure exerted on the rocket during its flight. Will the rocket explode in midair?

    c. If the angle of launch is $\alpha = 82°$, determine the minimum atmospheric pressure exerted on the rocket during its flight. Will the rocket explode in midair?

    d. Find the largest launch angle α so that the rocket will not explode.

Section 7.1 Exercises

Find all solutions on the interval $0 \le \theta < 2\pi$

1. $2\sin(\theta) = -1$
2. $2\sin(\theta) = \sqrt{3}$
3. $2\cos(\theta) = 1$
4. $2\cos(\theta) = -\sqrt{2}$

Find all solutions

5. $2\sin\left(\dfrac{\pi}{4}x\right) = 1$
6. $2\sin\left(\dfrac{\pi}{3}x\right) = \sqrt{2}$
7. $2\cos(2t) = -\sqrt{3}$
8. $2\cos(3t) = -1$

9. $3\cos\left(\dfrac{\pi}{5}x\right) = 2$
10. $8\cos\left(\dfrac{\pi}{2}x\right) = 6$
11. $7\sin(3t) = -2$
12. $4\sin(4t) = 1$

Find all solutions on the interval $[0, 2\pi)$

13. $10\sin(x)\cos(x) = 6\cos(x)$
14. $-3\sin(t) = 15\cos(t)\sin(t)$

15. $\csc(2x) - 9 = 0$
16. $\sec(2\theta) = 3$

17. $\sec(x)\sin(x) - 2\sin(x) = 0$
18. $\tan(x)\sin(x) - \sin(x) = 0$

19. $\sin^2 x = \dfrac{1}{4}$
20. $\cos^2 \theta = \dfrac{1}{2}$

21. $\sec^2 x = 7$
22. $\csc^2 t = 3$

23. $2\sin^2 w + 3\sin w + 1 = 0$
24. $8\sin^2 x + 6\sin(x) + 1 = 0$

25. $2\cos^2 t + \cos(t) = 1$
26. $8\cos^2(\theta) = 3 - 2\cos(\theta)$

27. $4\cos^2(x) - 4 = 15\cos(x)$
28. $9\sin(w) - 2 = 4\sin^2(w)$

29. $12\sin^2(t) + \cos(t) - 6 = 0$
30. $6\cos^2(x) + 7\sin(x) - 8 = 0$

31. $\cos^2 \phi = -6\sin \phi$
32. $\sin^2 t = \cos t$

33. $\tan^3(x) = 3\tan(x)$
34. $\cos^3(t) = -\cos(t)$

35. $\tan^5(x) = \tan(x)$
36. $\tan^5(x) - 9\tan(x) = 0$

37. $4\sin(x)\cos(x) + 2\sin(x) - 2\cos(x) - 1 = 0$

38. $2\sin(x)\cos(x) - \sin(x) + 2\cos(x) - 1 = 0$

39. $\tan(x) - 3\sin(x) = 0$
40. $3\cos(x) = \cot(x)$

41. $2\tan^2(t) = 3\sec(t)$
42. $1 - 2\tan(w) = \tan^2(w)$

Section 7.2 Exercises

Find an exact value for each of the following
1. $\sin(75°)$ 2. $\sin(195°)$ 3. $\cos(165°)$ 4. $\cos(345°)$

5. $\cos\left(\dfrac{7\pi}{12}\right)$ 6. $\cos\left(\dfrac{\pi}{12}\right)$ 7. $\sin\left(\dfrac{5\pi}{12}\right)$ 8. $\sin\left(\dfrac{11\pi}{12}\right)$

Rewrite in terms of $\sin(x)$ and $\cos(x)$
9. $\sin\left(x+\dfrac{11\pi}{6}\right)$ 10. $\sin\left(x-\dfrac{3\pi}{4}\right)$ 11. $\cos\left(x-\dfrac{5\pi}{6}\right)$ 12. $\cos\left(x+\dfrac{2\pi}{3}\right)$

Simplify each expression
13. $\csc\left(\dfrac{\pi}{2}-t\right)$ 14. $\sec\left(\dfrac{\pi}{2}-w\right)$ 15. $\cot\left(\dfrac{\pi}{2}-x\right)$ 16. $\tan\left(\dfrac{\pi}{2}-x\right)$

Rewrite the product as a sum
17. $16\sin(16x)\sin(11x)$ 18. $20\cos(36t)\cos(6t)$
19. $2\sin(5x)\cos(3x)$ 20. $10\cos(5x)\sin(10x)$

Rewrite the sum as a product
21. $\cos(6t)+\cos(4t)$ 22. $\cos(6u)+\cos(4u)$
23. $\sin(3x)+\sin(7x)$ 24. $\sin(h)+\sin(3h)$

25. Given $\sin(a)=\dfrac{2}{3}$ and $\cos(b)=-\dfrac{1}{4}$, and a and b are both in the interval $\left[\dfrac{\pi}{2},\pi\right)$

     a. Find $\sin(a+b)$ b. Find $\cos(a-b)$

26. Given $\sin(a)=\dfrac{4}{5}$ and $\cos(b)=\dfrac{1}{3}$, and a and b are both in the interval $\left[0,\dfrac{\pi}{2}\right)$

     a. Find $\sin(a-b)$ b. Find $\cos(a+b)$

Solve each equation for all solutions
27. $\sin(3x)\cos(6x)-\cos(3x)\sin(6x)=-0.9$
28. $\sin(6x)\cos(11x)-\cos(6x)\sin(11x)=-0.1$
29. $\cos(2x)\cos(x)+\sin(2x)\sin(x)=1$
30. $\cos(5x)\cos(3x)-\sin(5x)\sin(3x)=\dfrac{\sqrt{3}}{2}$

Solve each equation for all solutions

31. $\cos(5x) = -\cos(2x)$

32. $\sin(5x) = \sin(3x)$

33. $\cos(6\theta) - \cos(2\theta) = \sin(4\theta)$

34. $\cos(8\theta) - \cos(2\theta) = \sin(5\theta)$

Rewrite as a single function $A\sin(Bx + C)$

35. $4\sin(x) - 6\cos(x)$

36. $-\sin(x) - 5\cos(x)$

37. $5\sin(3x) + 2\cos(3x)$

38. $-3\sin(5x) + 4\cos(5x)$

Solve for the first two positive solutions

39. $-5\sin(x) + 3\cos(x) = 1$

40. $3\sin(x) + \cos(x) = 2$

41. $3\sin(2x) - 5\cos(2x) = 3$

42. $-3\sin(4x) - 2\cos(4x) = 1$

Simplify

43. $\dfrac{\sin(7t) + \sin(5t)}{\cos(7t) + \cos(5t)}$

44. $\dfrac{\sin(9t) - \sin(3t)}{\cos(9t) + \cos(3t)}$

Prove the identity

44. $\tan\left(x + \dfrac{\pi}{4}\right) = \dfrac{\tan(x) + 1}{1 - \tan(x)}$

45. $\tan\left(\dfrac{\pi}{4} - t\right) = \dfrac{1 - \tan(t)}{1 + \tan(t)}$

46. $\cos(a+b) + \cos(a-b) = 2\cos(a)\cos(b)$

47. $\dfrac{\cos(a+b)}{\cos(a-b)} = \dfrac{1 - \tan(a)\tan(b)}{1 + \tan(a)\tan(b)}$

48. $\dfrac{\tan(a+b)}{\tan(a-b)} = \dfrac{\sin(a)\cos(a) + \sin(b)\cos(b)}{\sin(a)\cos(a) - \sin(b)\cos(b)}$

49. $2\sin(a+b)\sin(a-b) = \cos(2b) - \cos(2a)$

50. $\dfrac{\sin(x) + \sin(y)}{\cos(x) + \cos(y)} = \tan\left(\dfrac{1}{2}(x+y)\right)$

51. $\dfrac{\cos(a+b)}{\cos(a)\cos(b)} = 1 - \tan(a)\tan(b)$

52. $\cos(x+y)\cos(x-y) = \cos^2 x - \sin^2 y$

Section 7.3 Exercises

1. If $\sin(x) = \dfrac{1}{8}$ and x is in quadrant 1, then find exact values for (without solving for x)

     a. $\sin(2x)$ b. $\cos(2x)$ c. $\tan(2x)$

2. If $\cos(x) = \dfrac{2}{3}$ and x is in quadrant 1, then find exact values for (without solving for x)

     a. $\sin(2x)$ b. $\cos(2x)$ c. $\tan(2x)$

Simplify the expressions

3. $\cos^2(28°) - \sin^2(28°)$ 4. $2\cos^2(37°) - 1$

5. $1 - 2\sin^2(17°)$ 6. $\cos^2(37°) - \sin^2(37°)$

7. $\cos^2(9x) - \sin^2(9x)$ 8. $\cos^2(6x) - \sin^2(6x)$

9. $4\sin(8x)\cos(8x)$ 10. $6\sin(5x)\cos(5x)$

Solve for all solutions on the interval $[0, 2\pi)$

11. $6\sin(2t) + 9\sin(t) = 0$ 12. $2\sin(2t) + 3\cos(t) = 0$

13. $9\cos(2\theta) = 9\cos^2(\theta) - 4$ 14. $8\cos(2\alpha) = 8\cos^2(\alpha) - 1$

15. $\sin(2t) = \cos(t)$ 16. $\cos(2t) = \sin(t)$

17. $\cos(6x) - \cos(3x) = 0$ 18. $\sin(4x) - \sin(2x) = 0$

Use the double angle, half angle, or power reduction formula to rewrite without exponents

19. $\cos^2(5x)$ 20. $\cos^2(6x)$

21. $\sin^4(8x)$ 22. $\sin^4(3x)$

23. $\cos^2 x \sin^4 x$ 24. $\cos^4 x \sin^2 x$

25. If $\csc(x) = 7$ and $90° < x < 180°$, then find exact values for (without solving for x)

     a. $\sin\left(\dfrac{x}{2}\right)$ b. $\cos\left(\dfrac{x}{2}\right)$ c. $\tan\left(\dfrac{x}{2}\right)$

26. If $\sec(x) = 4$ and $90° < x < 180°$, then find exact values for (without solving for x)

     a. $\sin\left(\dfrac{x}{2}\right)$ b. $\cos\left(\dfrac{x}{2}\right)$ c. $\tan\left(\dfrac{x}{2}\right)$

Prove the identity

27. $\left(\sin t - \cos t\right)^2 = 1 - \sin\left(2t\right)$

28. $\left(\sin^2 x - 1\right)^2 = \cos\left(2x\right) + \sin^4 x$

29. $\sin\left(2x\right) = \dfrac{2\tan\left(x\right)}{1 + \tan^2\left(x\right)}$

30. $\tan\left(2x\right) = \dfrac{2\sin\left(x\right)\cos\left(x\right)}{2\cos^2\left(x\right) - 1}$

31. $\cot\left(x\right) - \tan\left(x\right) = 2\cot\left(2x\right)$

32. $\dfrac{\sin\left(2\theta\right)}{1 + \cos\left(2\theta\right)} = \tan\left(\theta\right)$

33. $\cos\left(2\alpha\right) = \dfrac{1 - \tan^2\left(\alpha\right)}{1 + \tan^2\left(\alpha\right)}$

34. $\dfrac{1 + \cos\left(2t\right)}{\sin\left(2t\right) - \cos\left(t\right)} = \dfrac{2\cos\left(t\right)}{2\sin\left(t\right) - 1}$

35. $\sin\left(3x\right) = 3\sin\left(x\right)\cos^2\left(x\right) - \sin^3\left(x\right)$

36. $\cos\left(3x\right) = \cos^3\left(x\right) - 3\sin^2\left(x\right)\cos\left(x\right)$

Section 7.4 Exercises

Find a possible formula for the trigonometric function whose values are in the following tables.

1.

x	0	3	6	9	12	15	18
y	-4	-1	2	-1	-4	-1	2

2.

x	0	2	4	6	8	10	12
y	5	1	-3	1	5	1	-3

1. The displacement $h(t)$, in centimeters, of a mass suspended by a spring is modeled by the function $h(t) = 8\sin(6\pi t)$, where t is measured in seconds. Find the amplitude, period, and frequency of this function.

2. The displacement $h(t)$, in centimeters, of a mass suspended by a spring is modeled by the function $h(t) = 11\sin(12\pi t)$, where t is measured in seconds. Find the amplitude, period, and frequency of this function.

3. A population of rabbits oscillates 19 above and below average during the year, hitting the lowest value in January. The average population starts at 650 rabbits and increases by 160 each year. Find an equation for the population, P, in terms of the months since January, t.

4. A population of deer oscillates 15 above and below average during the year, hitting the lowest value in January. The average population starts at 800 deer and increases by 110 each year. Find an equation for the population, P, in terms of the months since January, t.

5. A population of muskrats oscillates 33 above and below average during the year, hitting the lowest value in January. The average population starts at 900 muskrats and increases by 7% each month. Find an equation for the population, P, in terms of the months since January, t.

6. A population of fish oscillates 40 above and below average during the year, hitting the lowest value in January. The average population starts at 800 fish and increases by 4% each month. Find an equation for the population, P, in terms of the months since January, t.

7. A spring is attached to the ceiling and pulled 10 cm down from equilibrium and released. The amplitude decreases by 15% each second. The spring oscillates 18 times each second. Find an equation for the distance, D the end of the spring is below equilibrium in terms of seconds, t.

8. A spring is attached to the ceiling and pulled 7 cm down from equilibrium and released. The amplitude decreases by 11% each second. The spring oscillates 20 times each second. Find an equation for the distance, D the end of the spring is below equilibrium in terms of seconds, t.

9. A spring is attached to the ceiling and pulled 17 cm down from equilibrium and released. After 3 seconds the amplitude has decreased to 13 cm. The spring oscillates 14 times each second. Find an equation for the distance, D the end of the spring is below equilibrium in terms of seconds, t.

10. A spring is attached to the ceiling and pulled 19 cm down from equilibrium and released. After 4 seconds the amplitude has decreased to 14 cm. The spring oscillates 13 times each second. Find an equation for the distance, D the end of the spring is below equilibrium in terms of seconds, t.

Match each equation form with one of the graphs

13. a. $ab^x + \sin(5x)$ b. $\sin(5x) + mx + b$

14. a. $ab^x \sin(5x)$ b. $(mx+b)\sin(5x)$

I   II   III   IV
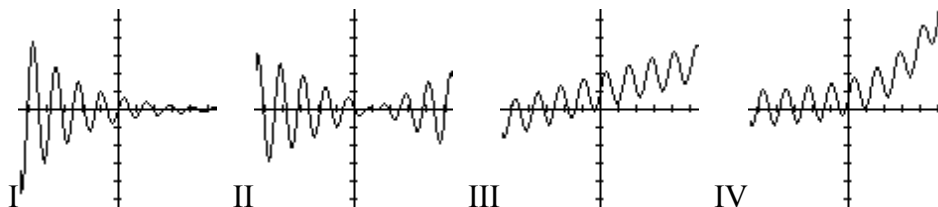
Find an equation of the form $y = ab^x + c\sin\left(\dfrac{\pi}{2}x\right)$ that fits the data given

15.
x	0	1	2	3
y	6	29	96	379

16.
x	0	1	2	3
y	6	34	150	746

Find an equation of the form $y = a\sin\left(\dfrac{\pi}{2}x\right) + m + bx$ that fits the data given

17.
x	0	1	2	3
y	7	6	11	16

18.
x	0	1	2	3
y	-2	6	4	2

Find an equation of the form $y = ab^x \cos\left(\dfrac{\pi}{2}x\right) + c$ that fits the data given

19.
x	0	1	2	3
y	11	3	1	3

20.
x	0	1	2	3
y	4	1	-11	1

Section 8.1 Exercises

Solve for the unknown sides and angles of the triangles shown.
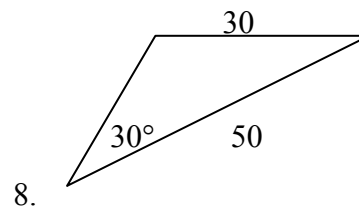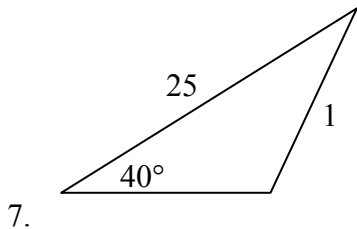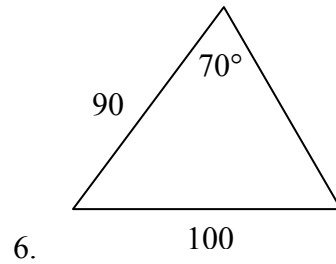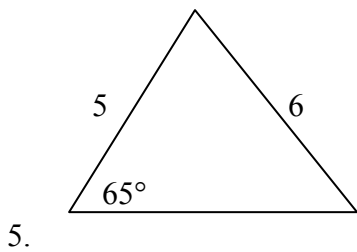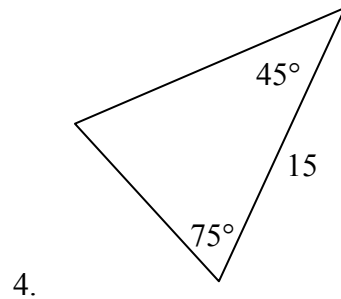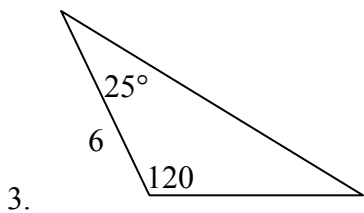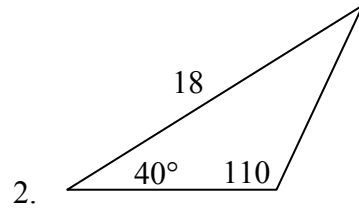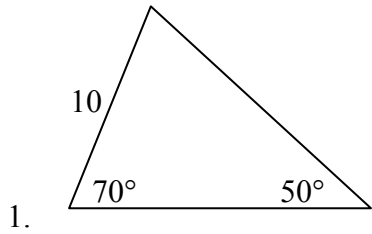
1.

10, 70°, 50°

2.

18, 40°, 110

3.

25°, 6, 120

4.

45°, 15, 75°

5.

5, 6, 65°

6.

70°, 90, 100

7.

25, 1, 40°

8.

30, 30°, 50

Assume $\angle A$ is opposite side a, $\angle B$ is opposite side b, and $\angle C$ is opposite side c. Solve each triangle for the unknown sides and angles if possible. If there is more than one possible solution, give both.

9. $\angle A = 43°, \angle C = 69°, b = 20$

10. $\angle A = 35°, \angle C = 73°, b = 19$

11. $\angle A = 119°, a = 26, b = 14$

12. $\angle C = 113°, b = 10, c = 32$

13. $\angle B = 50°, a = 105, b = 45$

14. $\angle B = 67°, a = 49, b = 38$

15. $\angle A = 43.1°, a = 184.2, b = 242.8$

16. $\angle A = 36.6°, a = 186.2, b = 242.2$

Solve for the unknown sides and angles of the triangles shown.
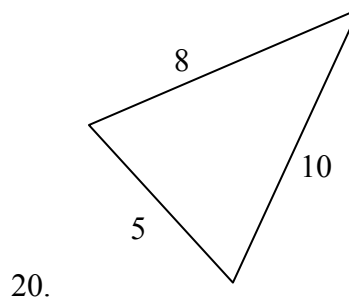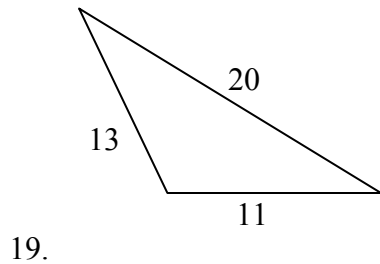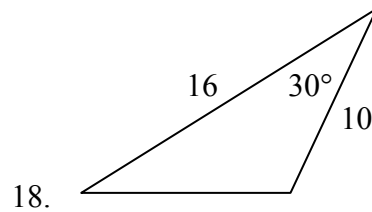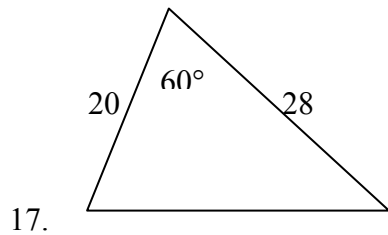
17.

18.

19.

20.

Assume $\angle A$ is opposite side a, $\angle B$ is opposite side b, and $\angle C$ is opposite side c. Solve each triangle for the unknown sides and angles if possible. If there is more than one possible solution, give both.

21. $\angle C = 41.2°, a = 2.49, b = 3.13$ 22. $\angle B = 58.7°, a = 10.6, c = 15.7$

23. $\angle A = 120°, b = 6, c = 7$ 24. $\angle C = 115°, a = 18, b = 23$

25. Find the area of a triangle with sides length 18, 21, and 32

26. Find the area of a triangle with sides length 20, 26, 37

27. To find the distance across a small lake, a surveyor has taken the measurements shown. Find the distance across the lake.

800 ft   70°   900 ft
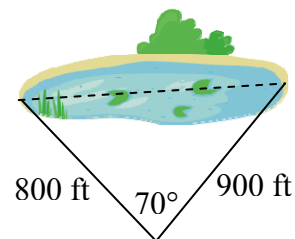
28. To find the distance between two cities, a satellite calculates the distances and angle shown (*not to scale*). Find the distance between the cities.

370 km   2.1°   350 km
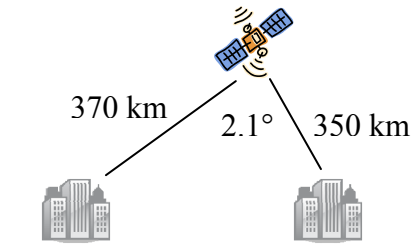
29. To determine how far a boat is from shore, two radar stations 500 feet apart determine the angles out to the boat, as shown. Find the distance of the boat from the station A, and the distance of the boat from shore.
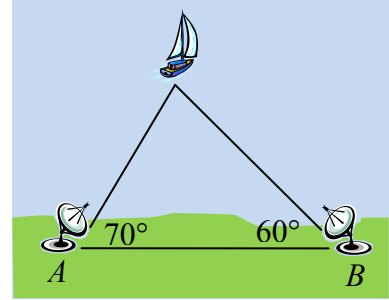
30. The path of a satellite orbiting the earth causes it to pass directly over two tracking stations A and B, which are 69 mi apart. When the satellite is on one side of the two stations, the angles of elevation at A and B are measured to be 86.2° and 83.9°, respectively. How far is the satellite from station A and how high is the satellite above the ground?
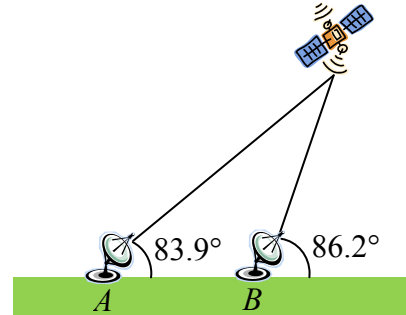
31. A communications tower is located at the top of a steep hill, as shown. The angle of inclination of the hill is 67°. A guy wire is to be attached to the top of the tower and to the ground, 165 m downhill from the base of the tower. The angle formed by the guy wire is 16°. Find the length of the cable required for the guy wire.
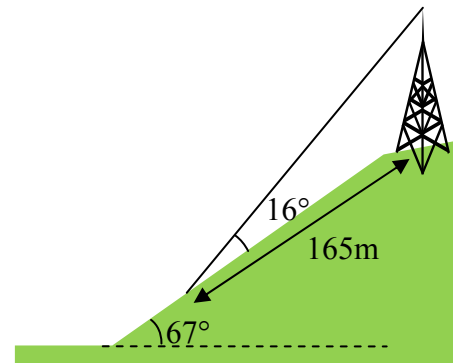
32. The roof of a house is at a 20° angle. An 8 foot solar panel is to be mounted on the roof, and should be angled 38° for optimal results. How long does the vertical support holding up the back of the panel need to be?
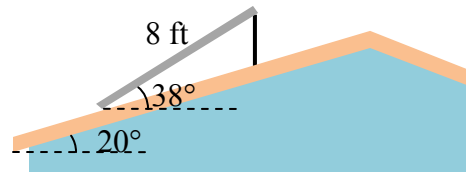
33. A 127 foot tower is located on a hill that is inclined 38° to the horizontal. A guy wire is to be attached to the top of the tower and anchored at a point 64 feet downhill from the base of the tower. Find the length of wire needed.
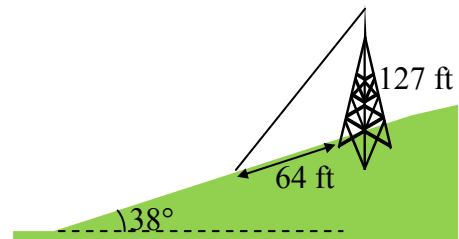
34. A 113 foot tower is located on a hill that is inclined 34° to the horizontal. A guy wire is to be attached to the top of the tower and anchored at a point 98 feet uphill from the base of the tower. Find the length of wire needed.

113 ft
98 ft
34°
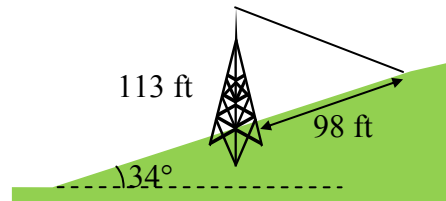
35. A pilot is flying over a straight highway. He determines the angles of depression to two mileposts, 6.6 km apart, to be 37° and 44°, as shown in the figure. Find the distance of the plane from point A, and the elevation of the plane.

37° 44°
A B
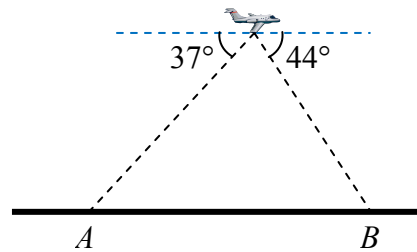
36. A pilot is flying over a straight highway. He determines the angles of depression to two mileposts, 4.3 km apart, to be 32° and 56°, as shown in the figure. Find the distance of the plane from point A, and the elevation of the plane.

32° 56°
A B
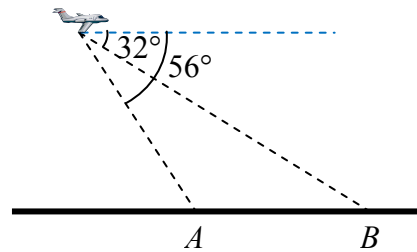
37. To estimate the height of a building, two students find the angle of elevation from a point (at ground level) down the street from the building to the top of the building is 39°. From a point that is 300 feet closer to the building, the angle of elevation (at ground level) to the top of the building is 50°. If we assume that the street is level, use this information to estimate the height of the building.

38. To estimate the height of a building, two students find the angle of elevation from a point (at ground level) down the street from the building to the top of the building is 35°. From a point that is 300 feet closer to the building, the angle of elevation (at ground level) to the top of the building is 53°. If we assume that the street is level, use this information to estimate the height of the building.

39. A pilot flies in a straight path for 1 hour 30 min. She then makes a course correction, heading 10 degrees to the right of her original course, and flies 2 hours in the new direction. If she maintains a constant speed of 680 miles per hour, how far is she from her starting position?

40. Two planes leave the same airport at the same time. One flies at 20 degrees east of north at 500 miles per hour. The second flies at 30 east of south at 600 miles per hour. How far apart are the planes after 2 hours?

41. The four sequential sides of a quadrilateral have lengths 4.5 cm, 7.9 cm, 9.4 cm, and 12.9 cm. The angle between the two smallest sides is 117°. What is the area of this quadrilateral?

42. The four sequential sides of a quadrilateral have lengths 5.7 cm, 7.2 cm, 9.4 cm, and 12.8 cm. The angle between the two smallest sides is 106°. What is the area of this quadrilateral?

43. Three circles with radii 6, 7, and 8 respectively, all touch as shown.
    Find the shaded area bounded by the three circles.
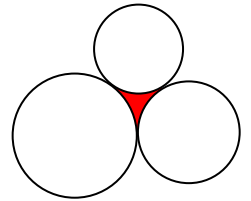
44. A rectangle is inscribed in a circle of radius 10 cm as shown. Find the shaded area, inside the circle but outside the rectangle.

55°
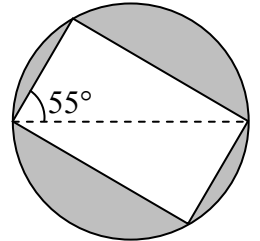
Section 8.2 Exercises

Convert the Polar coordinate to a Cartesian coordinate

1. $\left(7, \dfrac{7\pi}{6}\right)$ 2. $\left(6, \dfrac{3\pi}{4}\right)$ 3. $\left(4, \dfrac{7\pi}{4}\right)$ 4. $\left(9, \dfrac{4\pi}{3}\right)$

5. $\left(6, -\dfrac{\pi}{4}\right)$ 6. $\left(12, -\dfrac{\pi}{3}\right)$ 7. $\left(3, \dfrac{\pi}{2}\right)$ 8. $(5, \pi)$

9. $\left(-3, \dfrac{\pi}{6}\right)$ 10. $\left(-2, \dfrac{2\pi}{3}\right)$ 11. $(3, 2)$ 12. $(7, 1)$

Convert the Cartesian coordinate to a Polar coordinate

13. $(4, 2)$ 14. $(8, 8)$ 15. $(-4, 6)$ 16. $(-5, 1)$

17. $(3, -5)$ 18. $(6, -5)$ 19. $(-10, -13)$ 20. $(-4, -7)$

Convert the Cartesian equation to a Polar equation

21. $x = 3$ 22. $y = 4$ 23. $y = 4x^2$ 24. $y = 2x^4$

25. $x^2 + y^2 = 4y$ 26. $x^2 + y^2 = 3x$ 27. $x^2 - y^2 = x$ 28. $x^2 - y^2 = 3y$

Convert the Polar equation to a Cartesian equation

29. $r = 3\sin(\theta)$ 30. $r = 4\cos(\theta)$

31. $r = \dfrac{4}{\sin(\theta) + 7\cos(\theta)}$ 32. $r = \dfrac{6}{\cos(\theta) + 3\sin(\theta)}$

33. $r = 2\sec(\theta)$ 34. $r = 3\csc(\theta)$

35. $r = \sqrt{r\cos(\theta) + 2}$ 36. $r^2 = 4\sec(\theta)\csc(\theta)$

Match each equation with one of the graphs shown.

37. $r = 2 + 2\cos(\theta)$ 　　　　38. $r = 2 + 2\sin(\theta)$ 　　　　39. $r = 4 + 3\cos(\theta)$

40. $r = 3 + 4\cos(\theta)$ 　　　　41. $r = 5$ 　　　　　　　　42. $r = 2\sin(\theta)$

A 　　　　　　　　 B 　　　　　　　　 C

D 　　　　　　　　 E 　　　　　　　　 F
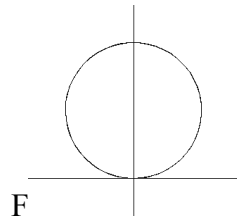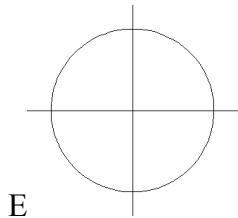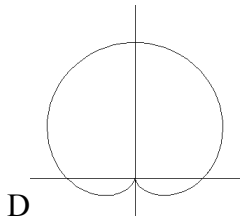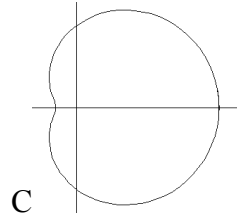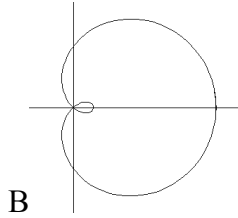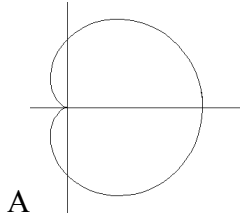
Match each equation with one of the graphs shown.

43. $r = \log(\theta)$ 　　　　　　44. $r = \theta\cos(\theta)$ 　　　　　　45. $r = \cos\left(\dfrac{\theta}{2}\right)$

46. $r = \sin(\theta)\cos^2(\theta)$ 　　　　47. $r = 1 + 2\sin(3\theta)$ 　　48. $r = 1 + \sin(2\theta)$

A 　　　　　　　　 B 　　　　　　　　 C

D 　　　　　　　　 E 　　　　　　　　 F
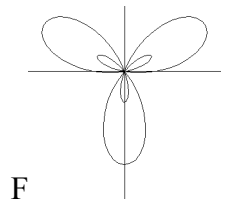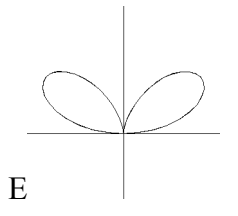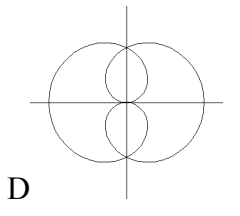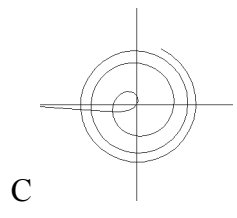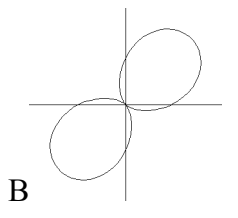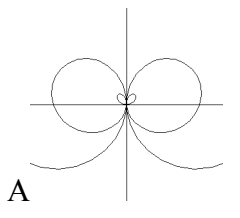
Sketch a graph of the polar equation

49. $r = 3\cos(\theta)$ 50. $r = 4\sin(\theta)$ 51. $r = 3\sin(2\theta)$

52. $r = 4\sin(4\theta)$ 53. $r = 5\sin(3\theta)$ 54. $r = 4\sin(5\theta)$

55. $r = 3\cos(2\theta)$ 56. $r = 4\cos(4\theta)$ 57. $r = 2 + 2\cos(\theta)$

58. $r = 3 + 3\sin(\theta)$ 59. $r = 1 + 3\sin(\theta)$ 60. $r = 2 + 4\cos(\theta)$

61. $r = 2\theta$ 62. $r = \dfrac{1}{\theta}$

63. $r = 3 + \sec(\theta)$, a conchoids   64. $r = \dfrac{1}{\sqrt{\theta}}$, a lituus[1]

65. $r = 2\sin(\theta)\tan(\theta)$, a cissoid   66. $r = 2\sqrt{1 - \sin^2(\theta)}$, a hippopede

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[1] This curve was the inspiration for the artwork featured on the cover of this book.

Section 8.3 Exercises

Simplify each expression to a single complex number

1. $\sqrt{-9}$

2. $\sqrt{-16}$

3. $\sqrt{-6}\sqrt{-24}$

4. $\sqrt{-3}\sqrt{-75}$

5. $\dfrac{2+\sqrt{-12}}{2}$

6. $\dfrac{4+\sqrt{-20}}{2}$

Simplify each expression to a single complex number

7. $(3+2i)+(5-3i)$

8. $(-2-4i)+(1+6i)$

9. $(-5+3i)-(6-i)$

10. $(2-3i)-(3+2i)$

11. $(2+3i)(4i)$

12. $(5-2i)(3i)$

13. $(6-2i)(5)$

14. $(-2+4i)(8)$

15. $(2+3i)(4-i)$

16. $(-1+2i)(-2+3i)$

17. $(4-2i)(4+2i)$

18. $(3+4i)(3-4i)$

19. $\dfrac{3+4i}{2}$

20. $\dfrac{6-2i}{3}$

21. $\dfrac{-5+3i}{2i}$

22. $\dfrac{6+4i}{i}$

23. $\dfrac{2-3i}{4+3i}$

24. $\dfrac{3+4i}{2-i}$

25. i^6

26. i^{11}

27. i^{17}

28. i^{24}

Rewrite each complex number from polar form into $a+bi$ form

29. $3e^{2i}$

30. $4e^{4i}$

31. $6e^{\frac{\pi}{6}i}$

32. $8e^{\frac{\pi}{3}i}$

33. $3e^{\frac{5\pi}{4}i}$

34. $5e^{\frac{7\pi}{4}i}$

Rewrite each complex number into polar $re^{i\theta}$ form

35. 6

36. -8

37. $-4i$

38. $6i$

39. $2+2i$

40. $4+4i$

41. $-3+3i$

42. $-4-4i$

43. $5+3i$

44. $4+7i$

45. $-3+i$

46. $-2+3i$

47. $-1-4i$

48. $-3-6i$

49. $5-i$

50. $1-3i$

Compute each of the following, leaving the result in polar $re^{i\theta}$ form

51. $\left(3e^{\frac{\pi}{6}i}\right)\left(2e^{\frac{\pi}{4}i}\right)$

52. $\left(2e^{\frac{2\pi}{3}i}\right)\left(4e^{\frac{5\pi}{3}i}\right)$

53. $\dfrac{6e^{\frac{3\pi}{4}i}}{3e^{\frac{\pi}{6}i}}$

54. $\dfrac{24e^{\frac{4\pi}{3}i}}{6e^{\frac{\pi}{2}i}}$

55. $\left(2e^{\frac{\pi}{4}i}\right)^{10}$

56. $\left(3e^{\frac{\pi}{6}i}\right)^{4}$

57. $\sqrt{16e^{\frac{2\pi}{3}i}}$

58. $\sqrt{9e^{\frac{3\pi}{2}i}}$

Compute each of the following, simplifying the result into $a+bi$ form

59. $(2+2i)^{8}$

60. $(4+4i)^{6}$

61. $\sqrt{-3+3i}$

62. $\sqrt{-4-4i}$

63. $\sqrt[3]{5+3i}$

64. $\sqrt[4]{4+7i}$

Solve each of the following equations for all complex solutions

65. $z^{5}=2$

66. $z^{7}=3$

67. $z^{6}=1$

68. $z^{8}=1$

Section 8.4 Exercises

Write the vector shown in component form

1.   2.
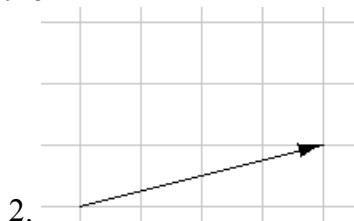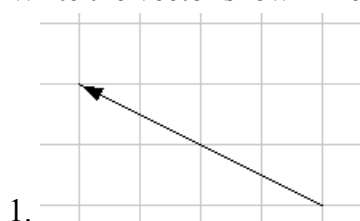
Given the vectors shown, sketch $\vec{u}+\vec{v}$, $\vec{u}-\vec{v}$, and $2\vec{u}$

3.   4.
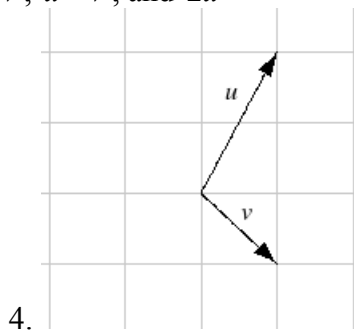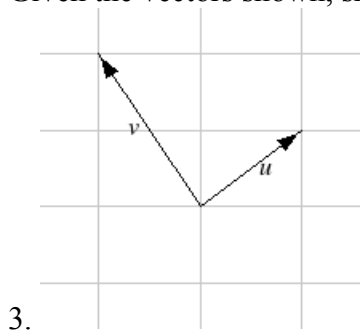
Write each vector below as a combination of the vectors $\vec{u}$ and $\vec{v}$ from question #3.

5.   6.
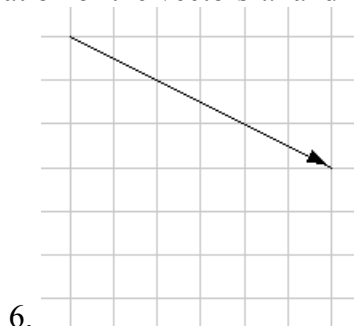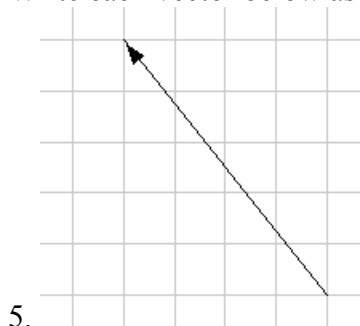
From the given magnitude and direction in standard position, write the vector in component form.

7. Magnitude: 6, Direction: 45°   8. Magnitude: 10, Direction: 120°
9. Magnitude: 8, Direction: 220°   10. Magnitude: 7, Direction: 305°

Find the magnitude and direction of the vector

11. $\langle 0,4 \rangle$ 12. $\langle -3,0 \rangle$ 13. $\langle 6,5 \rangle$ 14. $\langle 3,7 \rangle$

15. $\langle -2,1 \rangle$ 16. $\langle -10,13 \rangle$ 17. $\langle 2,-5 \rangle$ 18. $\langle 8,-4 \rangle$

19. $\langle -4,-6 \rangle$ 20. $\langle -1,9 \rangle$

Using the vectors given, compute $\vec{u}+\vec{v}$, $\vec{u}-\vec{v}$, and $2\vec{u}-3\vec{v}$

21. $\vec{u}=\langle 2,-3 \rangle$, $\vec{v}=\langle 1,5 \rangle$ 22. $\vec{u}=\langle -3,4 \rangle$, $\vec{v}=\langle -2,1 \rangle$

23. A woman leaves home and walks 3 miles west, then 2 miles southwest. How far from home is she, and what direction must she walk to head directly home?

24. A boat leaves the marina and sails 6 miles north, then 2 miles northeast. How far from the marina is the boat, and what direction must it sail to head directly back to the marina?

25. A person starts walking from home and walks 4 miles East, 2 miles Southeast, 5 miles South, 4 miles Southwest, and 2 miles East. How far total have they walked? If they walked straight home, how far would they have to walk?

26. A person starts walking from home and walks 4 miles East, 7 miles Southeast, 6 miles South, 5 miles Southwest, and 3 miles East. How far total have they walked? If they walked straight home, how far would they have to walk?

27. Three forces act on an object: $\vec{F}_1 = \langle -8, -5 \rangle$, $\vec{F}_2 = \langle 0, 1 \rangle$, $\vec{F}_3 = \langle 4, -7 \rangle$. Find the net force on the object.

28. Three forces act on an object: $\vec{F}_1 = \langle 2, 5 \rangle$, $\vec{F}_2 = \langle 8, 3 \rangle$, $\vec{F}_3 = \langle 0, -7 \rangle$. Find the net force on the object.

29. A person starts walking from home and walks 3 miles at 20° North of West, then 5 miles at 10° West of South, then 4 miles at 15° North of East. If they walked straight home, how far would they have to walk, and in what direction?

30. A person starts walking from home and walks 6 miles at 40° North of East, then 2 miles at 15° East of South, then 5 miles at 30° South of West. If they walked straight home, how far would they have to walk, and in what direction?

31. An airplane is heading north at an airspeed of 600 km/hr, but there is a wind blowing from the southwest at 80 km/hr. How many degrees off course will the plane end up flying, and what is the plane's speed relative to the ground?

32. An airplane is heading north at an airspeed of 500 km/hr, but there is a wind blowing from the northwest at 50 km/hr. How many degrees off course will the plane end up flying, and what is the plane's speed relative to the ground?

33. An airplane needs to head due north, but there is a wind blowing from the southwest at 60 km/hr. The plane flies with an airspeed of 550 km/hr. To end up flying due north, the pilot will need to fly the plane how many degrees west of north?

34. An airplane needs to head due north, but there is a wind blowing from the northwest at 80 km/hr. The plane flies with an airspeed of 500 km/hr. To end up flying due north, the pilot will need to fly the plane how many degrees west of north?

35. As part of a video game, the point (5, 7) is rotated counterclockwise about the origin through an angle of 35 degrees. Find the new coordinates of this point.

36. As part of a video game, the point (7, 3) is rotated counterclockwise about the origin through an angle of 40 degrees. Find the new coordinates of this point.

37. Two children are throwing a ball back-and-forth straight across the back seat of a car. The ball is being thrown 10 mph relative to the car, and the car is travelling 25 mph down the road. If one child doesn't catch the ball and it flies out the window, in what direction does the ball fly (ignoring wind resistance)?

38. Two children are throwing a ball back-and-forth straight across the back seat of a car. The ball is being thrown 8 mph relative to the car, and the car is travelling 45 mph down the road. If one child doesn't catch the ball and it flies out the window, in what direction does the ball fly (ignoring wind resistance)?

Section 8.5 Exercises

Match each of the equations with one of the graphs below.

1. $\begin{cases} x(t) = t \\ y(t) = t^2 - 1 \end{cases}$

2. $\begin{cases} x(t) = t - 1 \\ y(t) = t^2 \end{cases}$

3. $\begin{cases} x(t) = 4\sin(t) \\ y(t) = 2\cos(t) \end{cases}$

4. $\begin{cases} x(t) = 2\sin(t) \\ y(t) = 4\cos(t) \end{cases}$

5. $\begin{cases} x(t) = 2 + t \\ y(t) = 3 - 2t \end{cases}$

6. $\begin{cases} x(t) = -2 - 2t \\ y(t) = 3 + t \end{cases}$
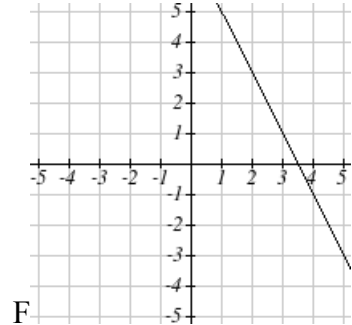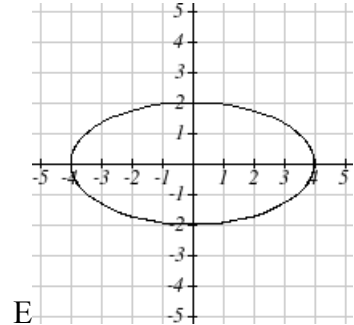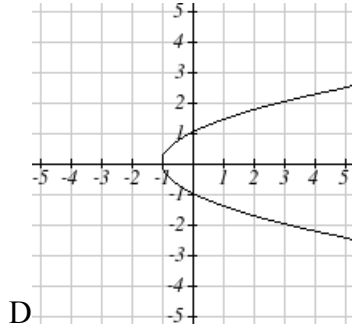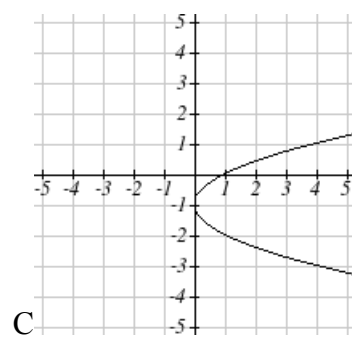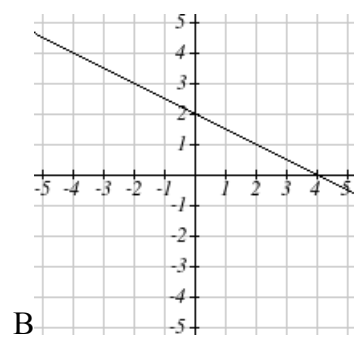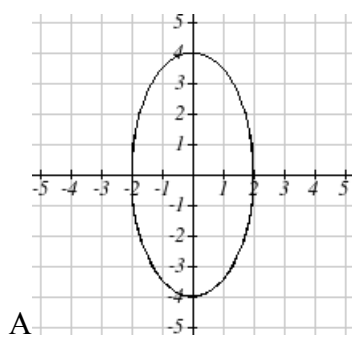
From each pair of graphs in the x-t and y-t planes shown, sketch a graph in the x-y plane.

7.

8.
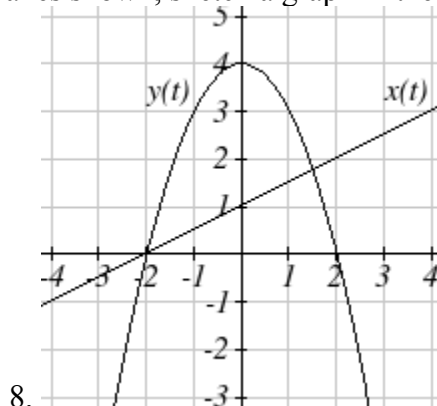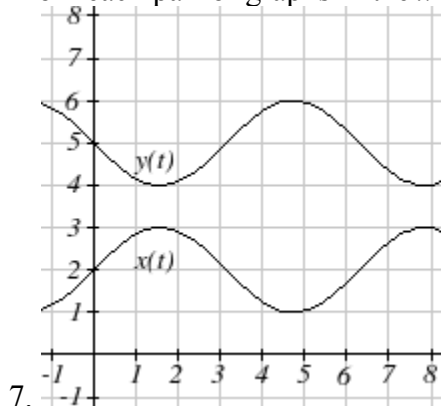
From each graph in the *x-y* plane shown, sketch a graph of the parameter functions in the *x-t* and *y-t* planes.

9.

10.
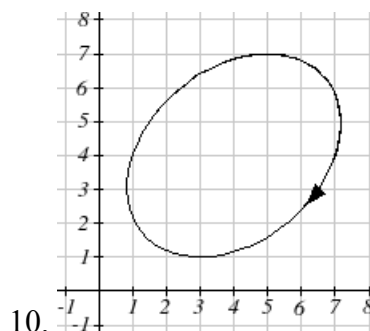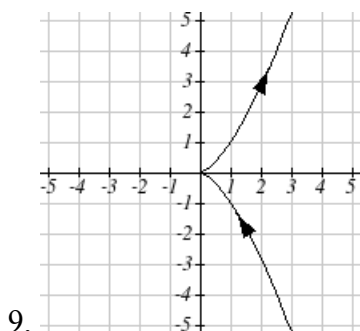
Sketch the parametric equation for $-2 \le t \le 2$

11. $\begin{cases} x(t) = 1 + 2t \\ y(t) = t^2 \end{cases}$

12. $\begin{cases} x(t) = 2t - 2 \\ y(t) = t^3 \end{cases}$

Eliminate the parameter *t* to rewrite the parametric equation as a Cartesian equation

13. $\begin{cases} x(t) = 5 - t \\ y(t) = 8 - 2t \end{cases}$

14. $\begin{cases} x(t) = 6 - 3t \\ y(t) = 10 - t \end{cases}$

15. $\begin{cases} x(t) = 2t + 1 \\ y(t) = 3\sqrt{t} \end{cases}$

16. $\begin{cases} x(t) = 3t - 1 \\ y(t) = 2t^2 \end{cases}$

17. $\begin{cases} x(t) = 2e^t \\ y(t) = 1 - 5t \end{cases}$

18. $\begin{cases} x(t) = 4\log(t) \\ y(t) = 3 + 2t \end{cases}$

19. $\begin{cases} x(t) = t^3 - t \\ y(t) = 2t \end{cases}$

20. $\begin{cases} x(t) = t - t^4 \\ y(t) = t + 2 \end{cases}$

21. $\begin{cases} x(t) = e^{2t} \\ y(t) = e^{6t} \end{cases}$

22. $\begin{cases} x(t) = t^5 \\ y(t) = t^{10} \end{cases}$

23. $\begin{cases} x(t) = 4\cos(t) \\ y(t) = 5\sin(t) \end{cases}$

24. $\begin{cases} x(t) = 3\sin(t) \\ y(t) = 6\cos(t) \end{cases}$

Parameterize (write a parametric equation for) each Cartesian equation

25. $y(x) = 3x^2 + 3$ 26. $y(x) = 2\sin(x) + 1$

27. $x(y) = 3\log(y) + y$ 28. $x(y) = \sqrt{y} + 2y$

29. $\dfrac{x^2}{4} + \dfrac{y^2}{9} = 1$ 30. $\dfrac{x^2}{16} + \dfrac{y^2}{36} = 1$

Parameterize the graphs shown
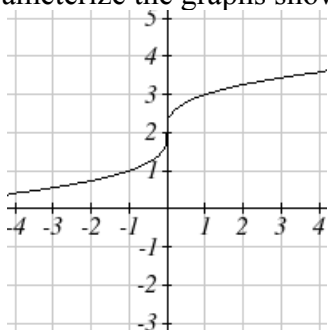
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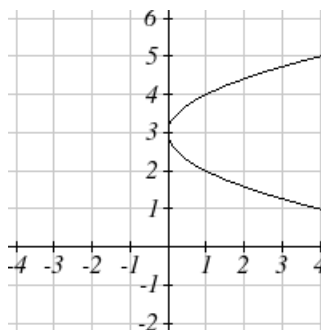
32.
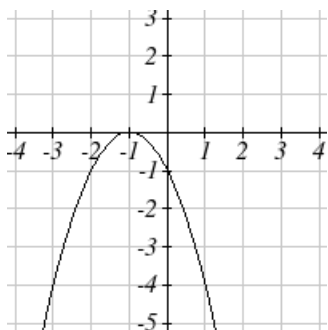
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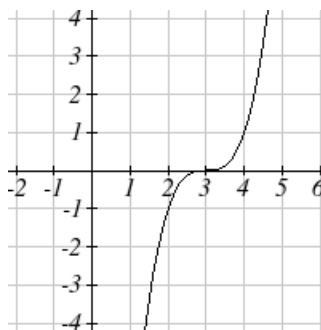
34.

35. Parameterize the line from $(-1,5)$ to $(2,3)$ so that the line is at $(-1,5)$ at $t = 0$, and at $(2,3)$ at $t = 1$.

36. Parameterize the line from $(4,1)$ to $(6,-2)$ so that the line is at $(4,1)$ at $t = 0$, and at $(6,-2)$ at $t = 1$.

The graphs below are created by parameteric equations of the form $\begin{cases} x(t) = a\cos(bt) \\ y(t) = c\sin(dt) \end{cases}$.

Find the values of *a, b, c,* and *d* to achieve each graph.

37.

38.

39.

40.
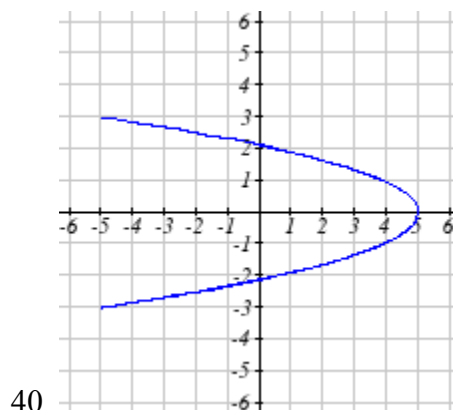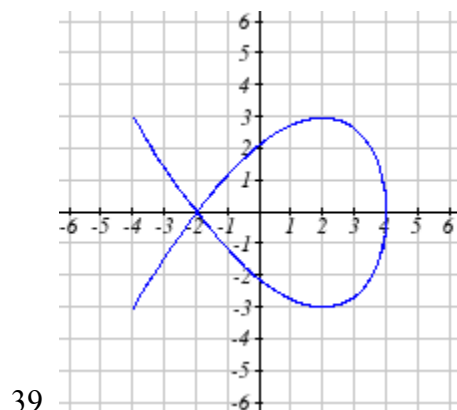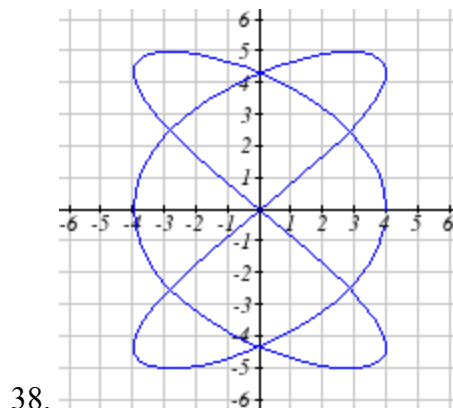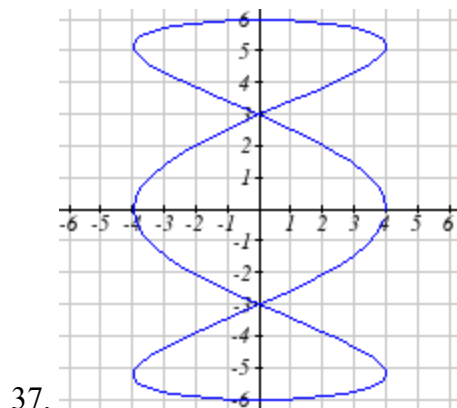
41. An object is thrown in the air with vertical velocity 20 ft/s and horizontal velocity 15 ft/s. The object's height can be described by the equation $y(t) = -16t^2 + 20t$, while the object moves horizontally with constant velocity 15 ft/s. Write parametric equations for the object's position, then eliminate time to write height as a function of horizontal position.

42. A skateboarder riding at a constant 9 ft/s throws a ball in the air, the height of which can be described by the equation $y(t) = -16t^2 + 10t + 5$. Write parametric equations for the ball's position, then eliminate time to write height as a function of horizontal position.

43. A carnival ride has a large rotating arm with diameter 40 feet centered 35 feet off the ground. At each end of the large arm are two smaller rotating arms with diameter 16 feet each. The larger arm rotates once every 5 seconds, while the smaller arms rotate once every 2 seconds. If you board the ride when the point P is closest to the ground, write a parametric equation for your position over time.
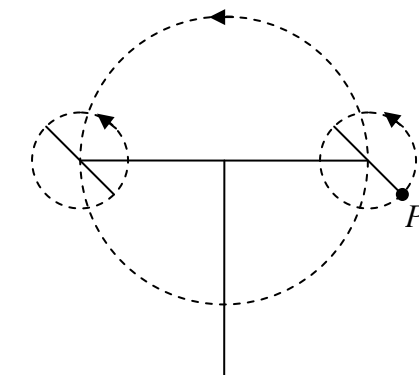
44. A hypocycloid is a shape is the shape generated by tracking a fixed point on a small circle as it rolls around the inside of a larger circle. If the smaller circle has radius 1 and the large circle has radius 6, find parametric equations for the position of the point P as the smaller wheel rolls in the direction indicated.
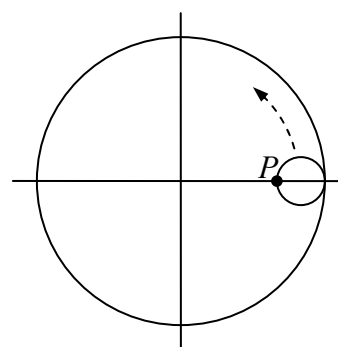
Solutions to Selected Exercises

Chapter 1

Section 1.1

1. a. $f(40)=13$

   b. 2 Tons of garbage per week is produced by a city with a population of 5,000.

3. a. In 1995 there are 30 ducks in the lake

   b. In 2000 there are 40 ducks in the late

5. a ,b, d, e	7. a, b	9. a, b, d
11. b	13. b, c, e, f	15. $f(1)=1,\ f(3)=1$
17. $g(2)=4,\ g(-3)=2$		19. $f(3)=53,\ f(2)=1$

	$f(-2)$	$f(-1)$	$f(0)$	$f(1)$	$f(2)$
21.	8	6	4	2	0
23.	49	18	34	4	21
25.	4	-1	0	1	-4
27.	4	4.414	4.732	5	5.236
29.	-4	-5	-6	-7	-8
31.	5	DNE	-3	-1	-1/3
33.	1/4	1/5	1	2	4

35. a. -6   b.-16   37. a. 5   b. $-\dfrac{5}{3}$

39. a. iii   b. viii c. I   d. ii   e. vi   f. iv   g. v   h. vii

41. a. iv   b. ii   c. v   d. I   e. vi   f. iii

43. $(x-3)^2+(y+9)^2=36$
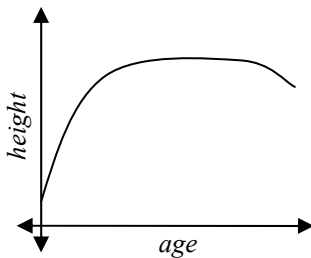
45. (a)   (b)
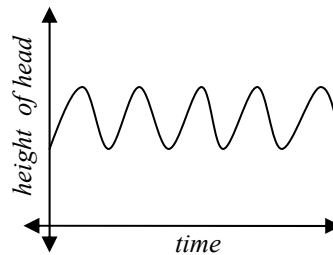
47a. L b. a c. r d. L: (c, t) and K: (a, p)

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Section 1.2

1. D: [-5, 3)   R: [0,2]   3. D: $2 < t \le 8$ R: $6 \le g(t) < 8$

5. D: [0,4]   R: [-3, 0]   7. $[2,\infty)$ 9. $(-\infty,3]$

11. $(-\infty,6)\cup(6,\infty)$ 13. $(-\infty,-\frac{1}{2})\cup\left(-\frac{1}{2},\infty\right)$

15. $[-4,4)\cup(4,\infty)$ 17. $(-\infty,-11)\cup(-11,2)\cup(2,\infty)$

	$f(-1)$	$f(0)$	$f(2)$	$f(4)$
19.	-4	6	20	34
21.	-1	-2	7	5
23.	-5	3	3	16

25. $f(x)=\begin{cases} 2 & if & -6 \le x \le -1 \\ -2 & if & -1 < x \le 2 \\ -4 & if & 2 < x \le 4 \end{cases}$ 27. $f(x)=\begin{cases} 3 & if & x \le 0 \\ x^2 & if & x > 0 \end{cases}$

29. $f(x)=\begin{cases} 2x+3 & if & -3 \le x < 1 \\ x-1 & if & -1 \le x \le 2 \\ -2 & if & 2 < x \le 5 \end{cases}$
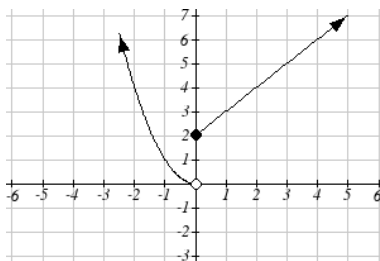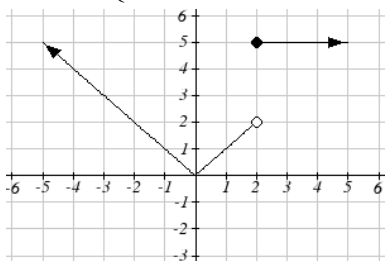
31.

33.
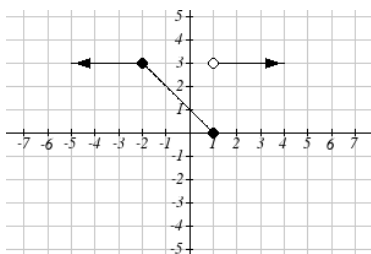
35.

Section 1.3

1. a) 6 million dollars per year   b) 2 million dollars per year

3. $\dfrac{4-5}{4-1}=-\dfrac{1}{3}$ 5. 6

7. 27   9. $\dfrac{352}{27}$

11. $4b+4$ 13. 3

15. $-\dfrac{1}{13h+169}$ 17. $9+9h+3h^2$

19. $4x+2h$

21. Increasing: $(-1.5,2)$. Decreasing: $(-\infty,-1.5)\cup(2,\infty)$

23. Increasing: $(-\infty,1)\cup(3,4)$. Decreasing: $(1,3)\cup(4,\infty)$

25. Increasing, concave up   27. Decreasing, concave down

29. Decreasing, concave up   31. Increasing, concave down

33. Concave up $(-\infty,1)$. Concave down $(1,\infty)$. Inflection point at (1, 2)

35. Concave down $(-\infty,3)\cup(3,\infty)$

37. Local minimum at (3, -22). Inflection at (2, -11).
Increasing on $(3,\infty)$. Decreasing $(-\infty,3)$
Concave up $(-\infty,0)\cup(2,\infty)$. Concave down $(0,2)$
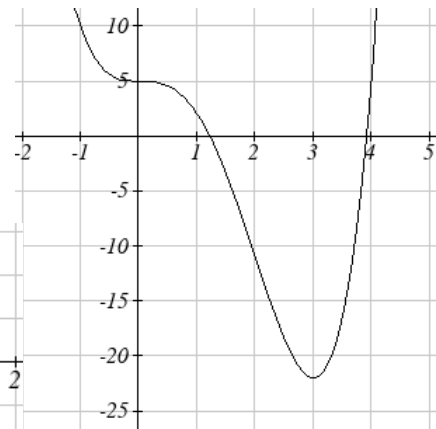
39. Local minimum at (-2, -2)
Decreasing $(-3,-2)$
Increasing $(-2,\infty)$
Concave up $(-3,\infty)$
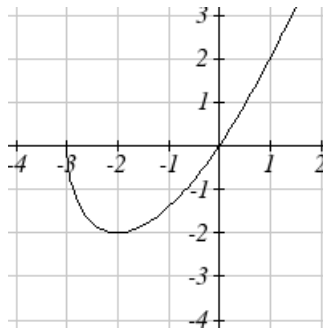
41. Local minimums at (-3.152, -47.626)
and (2.041, -32.041)
Local maximum at (-0.389, 5.979)
Inflection points at (-2, -24) and (1, -15)
Increasing $(-3.152,-0.389)\cup(2.041,\infty)$
Decreasing $(-\infty,-3.152)\cup(-0.389,2.041)$
Concave up $(-\infty,-2)\cup(1,\infty)$
Concave down $(-2,1)$
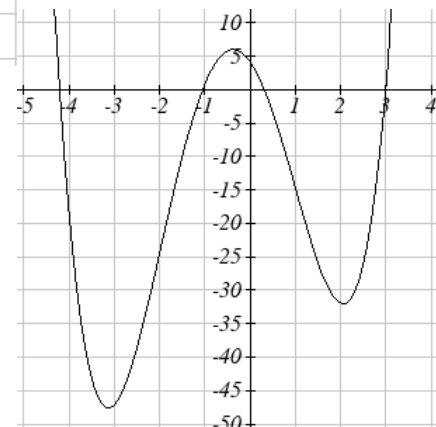
Section 1.4

1. $f(g(0)) = 36$. $g(f(0)) = -57$

3. $f(g(0)) = 4$. $g(f(0)) = 4$

5. 4   7. 9   9. 4   11. 7   13. 0   15. 4   17. 3   19. 2

21. $f(g(x)) = \dfrac{x}{7}$ $\qquad\qquad\qquad$ $g(f(x)) = 7x - 36$

23. $f(g(x)) = x + 3$ $\qquad\qquad\qquad$ $g(f(x)) = \sqrt{x^2 + 3}$

25. $f(g(x)) = |5x + 1|$ $\qquad\qquad\qquad$ $g(f(x)) = 5|x| + 1$

27. $f(g(h(x))) = \left(\sqrt{x} - 6\right)^4 + 6$

29a. $(0, 2) \cup (2, \infty)$ $\qquad$ b. $(-\infty, 2) \cup (2, \infty)$ $\qquad$ c. $(0, \infty)$

31. b $\qquad\qquad\qquad\qquad\qquad$ 33a. $r(V(t)) = \sqrt[3]{\dfrac{3(10 + 20t)}{4\pi}}$ b. 208.94

35. $g(x) = x + 2, f(x) = x^2$ $\qquad\qquad$ 37. $f(x) = \dfrac{3}{x}, g(x) = x - 5$

39. $f(x) = 3 + \sqrt{x}, g(x) = x - 2$, or $f(x) = 3 + x, g(x) = \sqrt{x - 2}$

41a. $f(f(x)) = a(ax + b) + b = \left(a^2\right)x + (ab + b)$ $\qquad$ b. $g(x) = \sqrt{6}x + \dfrac{8}{\sqrt{6} + 1}$

43a. $C(f(s)) = \dfrac{70\left(\dfrac{s}{60}\right)^2}{10 + \left(\dfrac{s}{60}\right)^2}$ $\qquad$ b. $C(g(h)) = \dfrac{70(60h)^2}{10 + (60h)^2}$

c. $v(C(m)) = \dfrac{5280}{3600}\left(\dfrac{70m^2}{10 + m^2}\right)$

Section 1.5

1. Horizontal shift right 49 units $\qquad\qquad$ 3. Horizontal shift left 3 units

5. Vertical shift up 5 units $\qquad\qquad$ 7. Vertical shift down 2 units

9. Horizontal shift right 2 units, Vertical shift up 3 units

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

13. $f(x-3)-4= \dfrac{1}{x-3}-4$

15. $g(x)= f(x-1), \quad h(x)= f(x)+1$

17.

19.

21.

23.
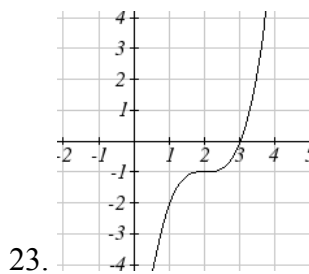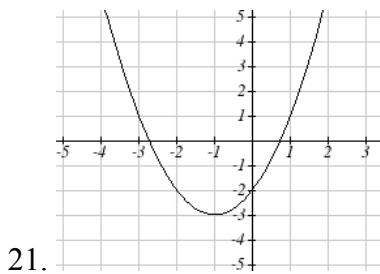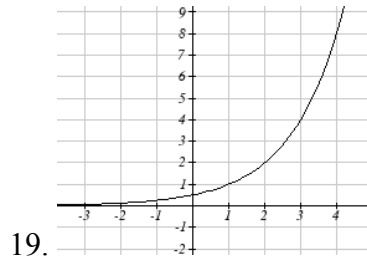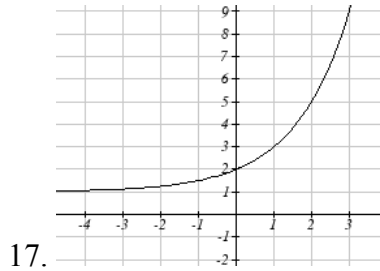
25. $y =|x-3|-2$

27. $y = \sqrt{x+3}-1$

29. $y = -\sqrt{x}$

31.
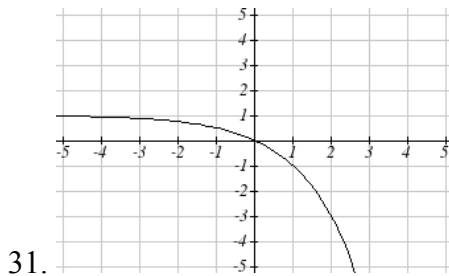
33a. $-f(-x)= -6^{-x}$

b. $-f(x+2)-3 = -6^{x+2}-3$

35. $y = -(x+1)^{2}+2$

37. $y = \sqrt{-x}+1$

39a. Even   b. Neither   c. Odd

41. Reflect *f(x)* about the *x*-axis

43. Vertically stretch *y* values by 4

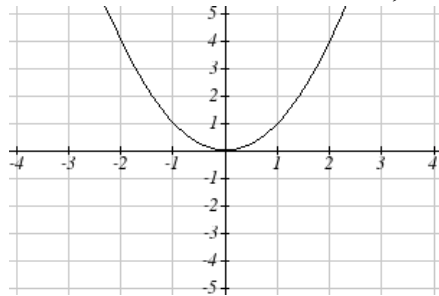45. Horizontally compress *x* values by 1/5

47. Horizontally stretch *x* values by 3

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49. Reflect *f(x)* about the *y*-axis and vertically stretch *y* values by 3

51. $f(-4x) = |-4x|$

53. $\dfrac{1}{3}f(x+2) - 3 = \dfrac{1}{3(x+2)^2} - 3$

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

57. Horizontal shift left 1 unit, vertical stretch y values by 4, vertical shift down 5 units

becomes
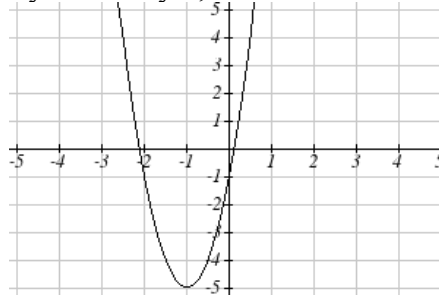
59. Horizontal shift right 4 units, vertical stretch y values by 2, reflect over x axis, vertically shift up 3 units.
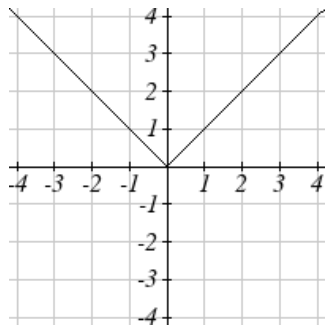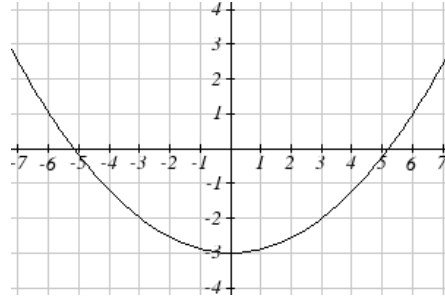

becomes
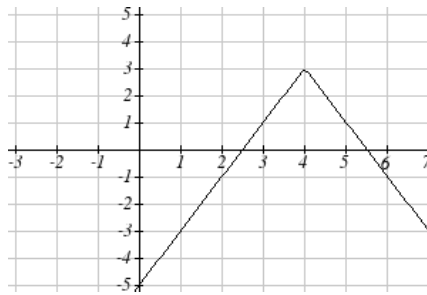
61. Vertically compress y values by ½
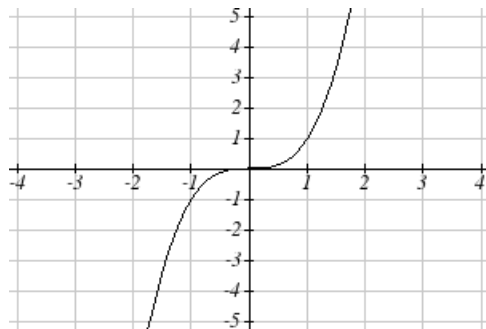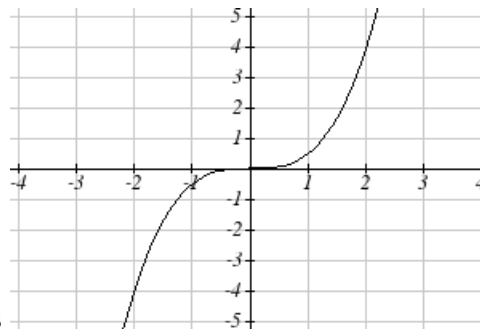
becomes

63. Horizontally stretch x values by 3, vertical shift down 3 units
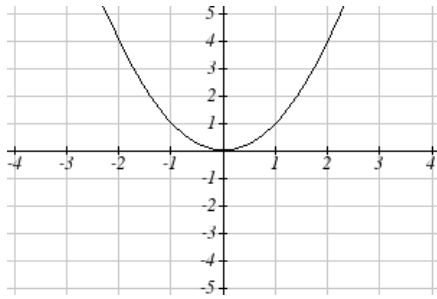
becomes

65. Reflected over the y axis, horizontally shift right 4 units $a(x) = \sqrt{-(x-4)}$
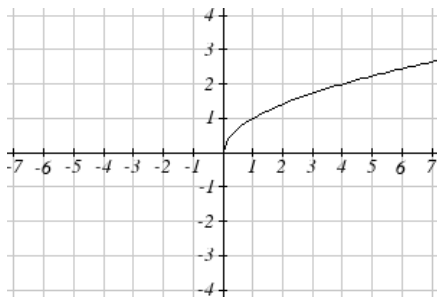
becomes
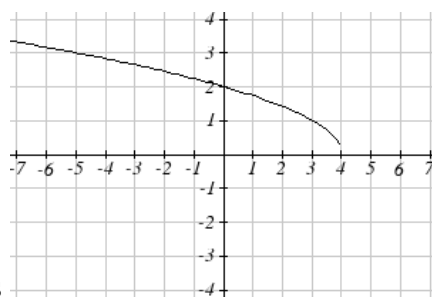
67. This function is increasing on $(-1,\infty)$ and decreasing on $(-\infty,-1)$

69. This function is decreasing on $(-\infty,4)$

71. This function is concave down on $(-3,\infty)$ and concave up on $(-\infty,-3)$

73. This function is concave up everywhere

75. $f(-x)$ 　　　　　　　　 77. $3f(x)$ 　　　　　　　　 79. $2f(-x)$

81. $2f\left(\dfrac{1}{2}x\right)$ 　　　　　　 83. $2f(x)-2$ 　　　　　　 85. $-f(x+1)+3$

87. $y = -2(x+2)^2 + 3$ 　　 89. $y = \left(\dfrac{1}{2}(x-1)\right)^3 + 2$ 　　 91. $y = \sqrt{2(x+2)}+1$

93. $y = \dfrac{-1}{(x-2)^2} + 3$ 　　 95. $y = -2|x+1|+3$ 　　 97. $y = \sqrt[3]{-(x-2)}+1$

99a. *Domain*: $3.5 \le x \le 6$ 　　　　 d. *Range*: $-9 \le y \le 7$

Section 1.6

1. 6   3. -4   5. ½

7a. 3   b. 2   c. 2   d. 3

9a. 0   b. 7   c. 1   d. 3

11.

x	1	4	7	12	16
$f^{-1}(x)$	3	6	9	13	14

13. $f^{-1}(x) = x - 3$ 15. $f^{-1}(x) = -x + 2$ 17. $f^{-1}(x) = \dfrac{x-7}{11}$

19. Restricted domain $x \geq -7, f^{-1}(x) = \sqrt{x} - 7$

21. Restricted domain $x \geq 0, \ f^{-1}(x) = \sqrt{x+5}$

23a. $f(g(x)) = \left(\sqrt[3]{x+5}\right)^3 - 5 = x$ b. $g(f(x)) = \sqrt[3]{x^3 - 5 + 5} = x$

   c. This means that they are inverse functions (of each other)

Chapter 2

Section 2.1

1. $P(t) = 1700t + 45000$ 3. $D(t) = 10 + 2t$ 5. $M(n) = 4 - 2n$

7. Increasing   9. Decreasing   11. Decreasing

13. Increasing   15. Decreasing   17. 3

19. $-\dfrac{1}{3}$ 21. $\dfrac{4}{5}$ 23. $\dfrac{2}{3}$

25. -0.05 mph   (or 0.05 miles per hour toward her home)

27. Population is decreasing by 400 people per year

29. Monthly charge in dollars has an initial base charge of $24, and increases by $0.10 for each minute talked

31. Terry started at an elevation of 3,000 ft and is descending by 70ft per second.

33. $y = \dfrac{3}{5}x - 1$ 35. $y = 3x - 2$ 37. $y = -\dfrac{1}{3}x + \dfrac{11}{3}$

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39. $y = -1.5x - 3$ 41. $y = \dfrac{2}{3}x + 1$ 43. $y = -2x + 3$

45. $P(n) = -0.004n + 34$

47. The 1st, 3rd & 4th tables are linear: respectively

     1. $g(x) = -3x + 5$ 3. $f(x) = 5x - 5$ 4. $k(x) = 3x - 2$
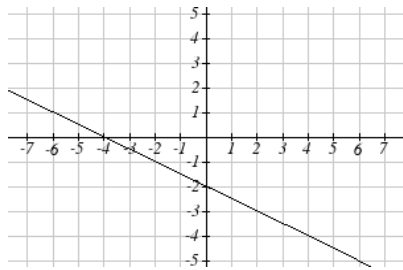
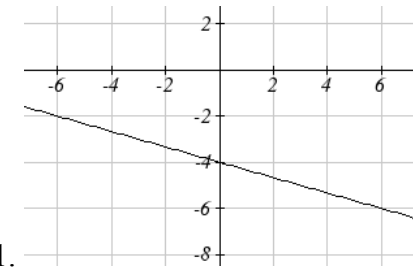49a. $C = \dfrac{5}{9}F - \dfrac{160}{9}$ b. $F = \dfrac{9}{5}C + 32$ c. $-9.4°F$
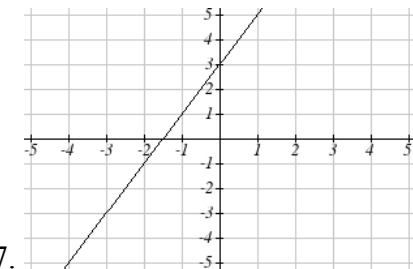
Section 2.2

1. E   3. D   5. B

7.

9.

11.

13.

17.

19.

21.

23. a. $g(x) = \dfrac{3}{4}(x + 2) - 4$ b. ¾   c. -5/2

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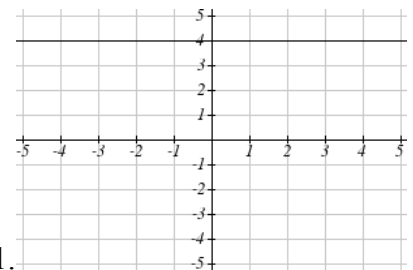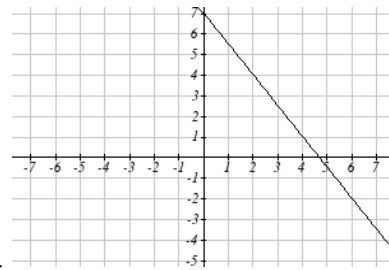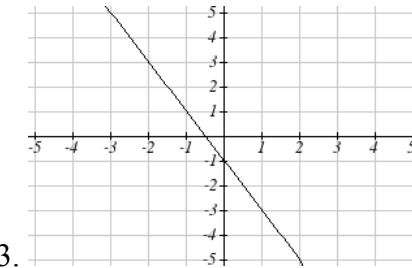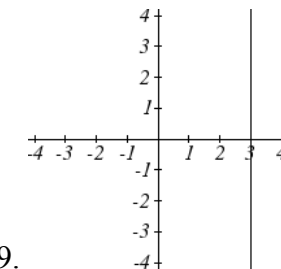
25. $y = 3$

27. $x = -3$

	Vertical Intercept	Horizontal Intercept
29.	(0,2)	(2,0)
31.	(0,-5)	(5/3, 0)
33.	(0,4)	(-10,0)

35. Line 1: $m = -10$ Line 2: $m = -10$ Parallel

37. Line 1: $m = -2$ Line 2: $m = 1$ Neither

39. Line 1: $m = -\dfrac{2}{3}$ Line 2: $m = \dfrac{3}{2}$ Perpendicular

41. $y = -5x - 2$ 43. $y = \dfrac{1}{2}t + 1$ 45. (-1,1)

47. (1.2, 10)   49. Plan B saves money if the miles are $> 111\dfrac{1}{9}$

Section 2.3

1a. 696 people   b. 4 years   c. 174 people per year

 d. 305 people   e. $P(t) = 305 + 174t$ f. 2219 people.

3a. $C(x) = 0.35x + 30$

 b. The flat monthly fee is $10 and there is an additional $0.15 fee for each additional minute used

 c. $113.05

5a. $P(t) = 190t + 4170$ b. 6640 moose

7a. $R(t) = 16 - 2.1t$ b. 5.5 billion cubic feet   c. During the year 2017

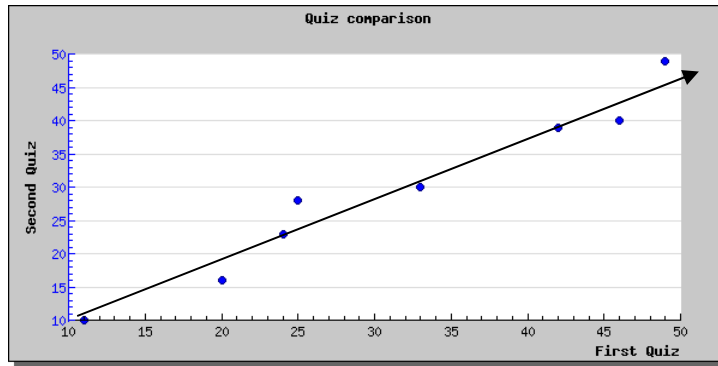9. More than 133 minutes   11. More than $42,857.14 worth of jewelry

13. 20.012 square units   15. 6 square units

17. $A = -\dfrac{b^2}{2m}$

19a. Hawaii   b. $80,640   c. During the year 1933

21. 26.225 miles

Section 2.4

1.

http://www.mathcracker.com/scatter_plot.php

3. $y = 1.971x - 3.519, \ r = 0.967$ 5. $y = -0.901x + 26.04, \ r = -0.968$
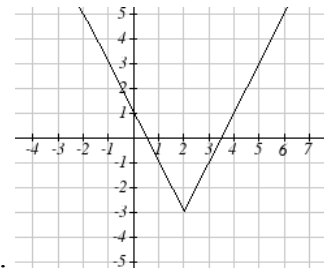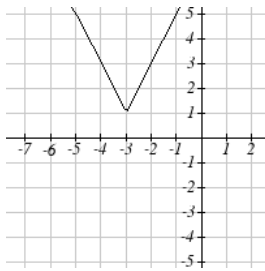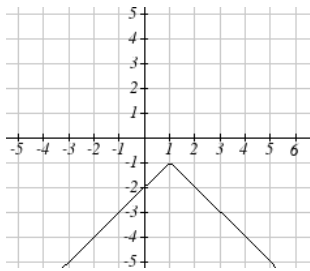
7. $17.483 \approx 17 \ situps$ 9. D   11. A

13. Yes, trend appears linear because $r = 0.994$ and will exceed 35% near the end of the year 2019.

Section 2.5

1. $y = \dfrac{1}{2}|x + 2| + 1$ 3. $y = -3|x - 3| + 3$

5.   7.   9.

11. $x = -\dfrac{9}{5} \ or \ x = \dfrac{13}{5}$ 13. $x = \dfrac{1}{2} \ or \ x = \dfrac{15}{2}$

15. $x = -\dfrac{5}{3} \ or \ x = -\dfrac{1}{3}$

	Horizontal Intercepts	Vertical Intercept
17.	(-6, 0) and (4, 0)	(0, -8)
19.	none	(0, -7)

21. $-11 < x < 1$ or $(-11,1)$

23. $x \geq 5$, $x \leq -1$ or $(-\infty, -1] \cup [5, \infty)$

25. $-\dfrac{13}{3} < x < -\dfrac{5}{3}$ or $(-\dfrac{13}{3}, -\dfrac{5}{3})$

Chapter 3

Section 3.1

1. As $x \to \infty$, $f(x) \to \infty$ As $x \to -\infty$, $f(x) \to \infty$
3. As $x \to \infty$, $f(x) \to \infty$ As $x \to -\infty$, $f(x) \to -\infty$
5. As $x \to \infty$, $f(x) \to -\infty$ As $x \to -\infty$, $f(x) \to -\infty$
7. As $x \to \infty$, $f(x) \to -\infty$ As $x \to -\infty$, $f(x) \to \infty$
9. 7th Degree, Leading coefficient 4
11. 2nd Degree, Leading coefficient -1
13. 4th Degree, Leading coefficient -2
15. 3rd Degree, Leading coefficient 6
17. As $x \to \infty$, $f(x) \to -\infty$ As $x \to -\infty$, $f(x) \to -\infty$
19. As $x \to \infty$, $f(x) \to \infty$ As $x \to -\infty$, $f(x) \to \infty$
21. intercepts: 5, turning points: 4   23. 3
25. 5   27. 3   29. 5
31. Horizontal Intercepts (1,0), (-2, 0), (3, 0)   Vertical Intercept (0, 12)
33. Horizontal Intercepts (1/3, 0) (-1/2, 0)   Vertical Intercept (0, 2)

Section 3.2

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

	Vertex	Vertical Intercept	Horizontal Intercepts	
7.	$(-2.5, -0.5)$	(0,12)	(-2, 0)	(-3, 0)
9.	$(2.5, -8.5)$	(0,4)	(0.438, 0)	(4.562,0)
11.	$(0.75, 1.25)$	(0,-1)	(0.191, 0)	(1.309, 0)

13. $f(x) = (x-6)^2 - 4$ 15. $f(x) = 2(x+2)^2 - 18$ 17. $b = 32$ and $c = -25$

19. $f(x) = -\frac{2}{3}(x+3)(x-1)$ 21. $f(x) = \frac{3}{5}(x-2)(x-5)$

23. $f(x) = -\frac{1}{4}(x-4)^2$ 25. $f(x) = -\frac{1}{9}(x+3)^2 + 2$

27a. 234m   b. 2909.561 ft   c. 47.735 seconds
29a. 3 ft   b. 111 ft   c. 72.497 ft
31. 24.91 in by 24.91 in

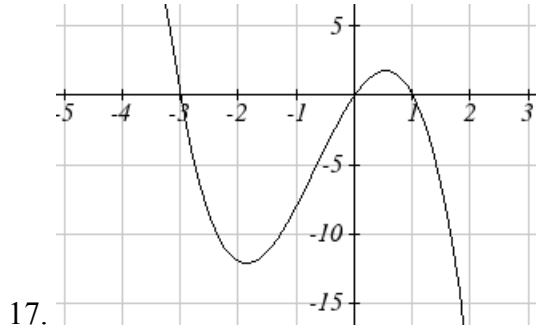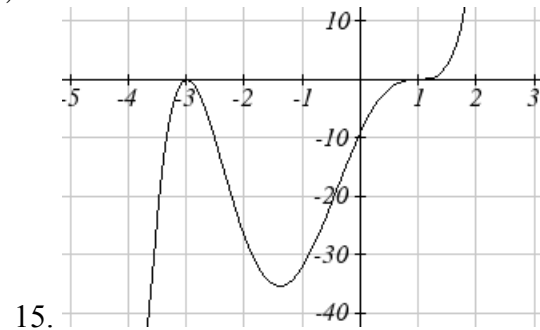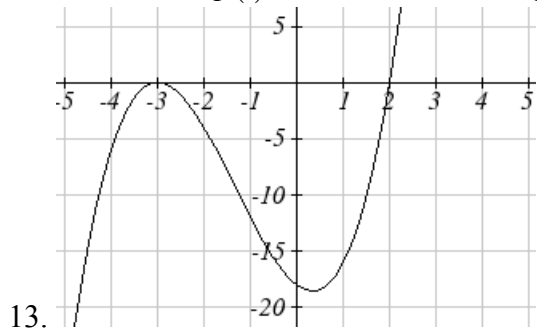33. 125 ft by $83\frac{1}{3}$ ft

35. 24.6344 cm
37. $10.70

Section 3.3

C(t)	C, intercepts	t, intercepts
1.	(0,48)	(4,0), (-1,0), (6,0)
3.	(0,0)	(0,0), (2,0), (-1,0)
5.	(0,0)	(0,0), (1,0), (3,0)

7. (-1.646, 0) (3.646, 0) (5,0)

9. As $t \to \infty, h(t) \to \infty$ $t \to -\infty, h(t) \to -\infty$

11. As $t \to \infty, p(t) \to -\infty$ $t \to -\infty, p(t) \to -\infty$

13.

15.

17.

19. $(3, \infty)$

21. $(-\infty, -2) \cup (1, 3)$

23. $[3.5, 6]$

25. $(-\infty, 1] \cup (4, \infty)$

27. $[3, \infty)$

29. $(-\infty, -4) \cup (-4, 2) \cup (2, \infty)$

31. $y = -\frac{2}{3}(x+2)(x-1)(x-3)$

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

35. $y = -15(x-1)^2(x-3)^3$

37. $y = \frac{1}{2}(x+2)(x-1)(x-3)$

39. $y = -(x+1)^2(x-2)$

41. $y = -\frac{1}{24}(x+3)(x+2)(x-2)(x-4)$

43. $y = \frac{1}{24}(x+4)(x+2)(x-3)^2$

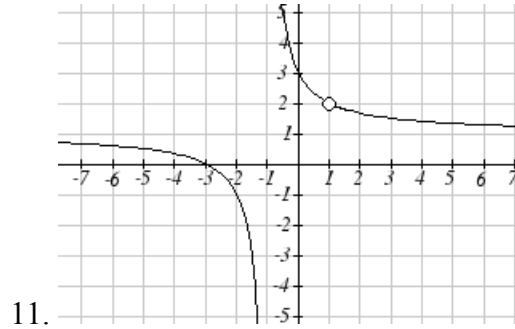45. $y = \frac{1}{12}(x+2)^2(x-3)^2$

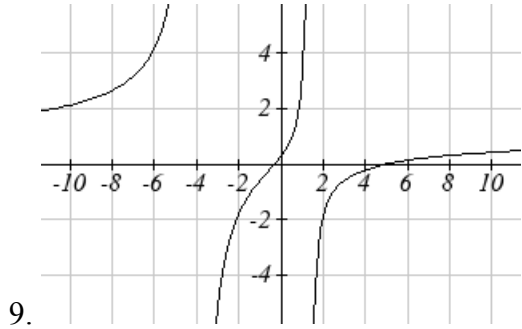47. $y = \frac{1}{6}(x+3)(x+2)(x-1)^3$

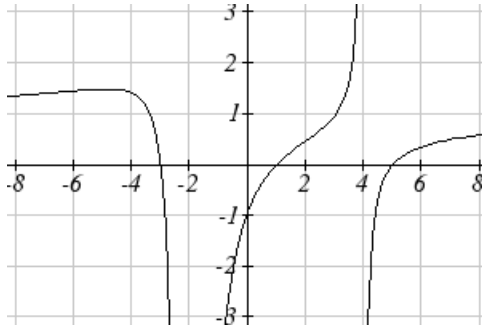49. $y = -\frac{1}{16}(x+3)(x+1)(x-2)^2(x-4)$

51. Base 2.58, Height 3.336

Section 3.4

1. D   3. A

	Vertical Asymptotes	Horizontal Asymptote	Vertical y-Intercept	Horizontal x-intercept
5.	$x = -4$	$y = 2$	(0,-3/4)	(3/2, 0)
7.	$x = 2$	$y = 0$	(0,1)	DNE
9.	$x = -4, 1\frac{1}{3}$	$y = 1$	(0, 5/16)	(-1/3, 0), (5,0)
11.	$x = -1$, hole at $x = 1$	$y = 1$	(0,3)	(-3, 0)
13.	$x = 4$	none y=2x (oblique)	(0, ¼)	(-1, 0), (1/2, 0)
15.	$x = 0,\ 4$	$y = 0$	DNE	(-2, 0), (2/3, 0)
17.	$x = -2,\ 4$	$y = 1$	(0, 15/16)	(1, 0), (-3, 0), (5, 0)

5.

7.

9.

11.

13.

15.
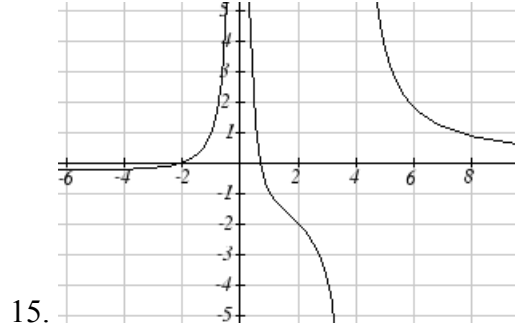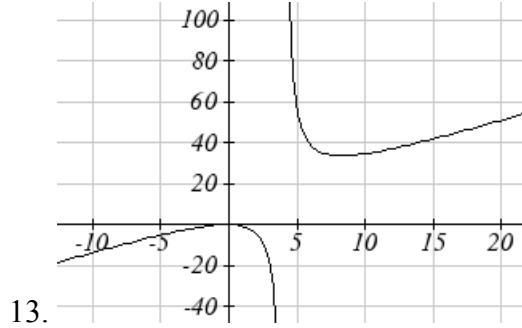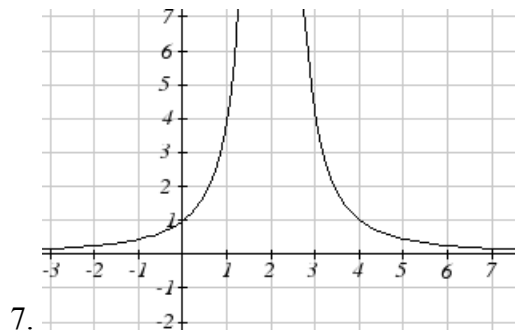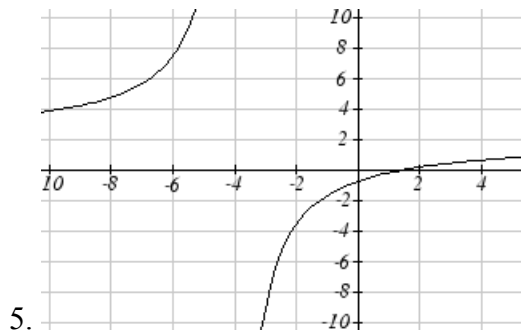
17.

19. $y = \dfrac{50(x-2)(x+1)}{(x+5)(x-5)}$

21. $y = \dfrac{7(x-4)(x+6)}{(x+4)(x+5)}$

23. $y = \dfrac{1(x-2)^2}{2(x+1)}$

25. $y = \dfrac{4(x-3)}{(x+3)(x-4)}$

27. $y = \dfrac{27(x-2)}{(x+3)(x-3)^2}$

29. $y = \dfrac{1(x+3)(x-2)}{3(x-1)}$

31. $y = \dfrac{6(x-1)^2}{(x+3)(x-2)^2}$

33. $y = -\dfrac{2(x)(x-3)}{(x+3)(x-4)}$

35. $y = \dfrac{2(x-1)^3}{(x+1)(x-2)^2}$

37. $y = \dfrac{(x-4)(x-2)}{(x-4)(x+1)}$

39. a. $C(n) = \dfrac{4}{20+n}$ b. $C(10) \approx 13.33\%$ c. 80 mL   d. as $n \to \infty, C \to 0$

Section 3.5

1. Domain $(4,\infty)$ Inverse $f^{-1}(x) = \sqrt{x} + 4$

3. Domain $(-\infty,0)$ Inverse $f^{-1}(x) = -\sqrt{12-x}$

5. Domain $(-\infty,\infty)$ Inverse $f^{-1}(x) = \sqrt[3]{\dfrac{x-1}{3}}$

7. $f^{-1}(x) = \dfrac{(x-9)^2}{4} + 1$

9. $f^{-1}(x) = \left(\dfrac{x-9}{2}\right)^3$

11. $f^{-1}(x) = \dfrac{2-8x}{x}$

13. $f^{-1}(x) = \dfrac{3-7x}{x-1}$

15. $f^{-1}(x) = \dfrac{5x-4}{3+4x}$

17. 65.574 mph

19. 34.073 mph

21. 14.142 feet

Chapter 4

Section 4.1

1. Linear	3. Exponential	5. Neither

7. $P(t) = 11,000(1.085)^t$ 9. 47622 Fox

11. $17561.70	13. $y = 6(5)^x$	15. $y = 2000(0.1)^x$

17. $y = 3(2)^x$ 19. $y = \left(\dfrac{1}{6}\right)^{-\frac{3}{5}}\left(\dfrac{1}{6}\right)^{\frac{x}{5}} = 2.93(0.699)^x$ 21. $y = \dfrac{1}{8}(2)^x$

23. $34.32\, mg$ 25. 1.39%; $155,368.09   27. $4,813.55

29. Annual $\approx$ $7353.84   Quarterly $\approx$ $7,469.63   Monthly $\approx$ $7,496.71
    Continuously $\approx$ $7,510.44

31. 3.03%   33. 7.4 years

35a. $w(t) = (1.113)(1.046)^t$ b. $1.11   c. Below what the model predicts $\approx$ $5.70

Section 4.2

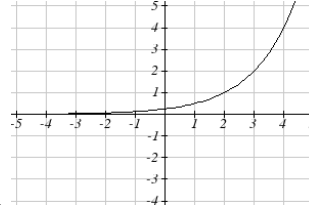|				
1. B	3. A	5. E	7. D	9. C

11.   13.   15.
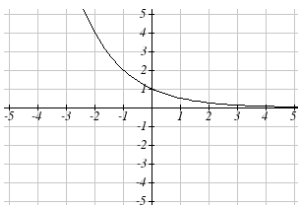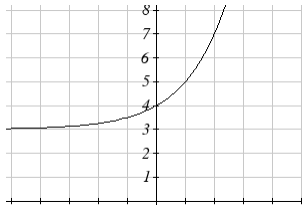
17. $y = 4^x + 4$ 19. $y = 4^{x+2}$ 21. $y = -4^x$

23. As $x \to \infty$ $f(x) \to -\infty$. As $x \to -\infty$ $f(x) \to -1$

25. As $x \to \infty$ $f(x) \to -2$ As $x \to -\infty$ $f(x) \to \infty$

27. As $x \to \infty$ $f(x) \to 2$ As $x \to -\infty$ $f(x) \to \infty$

29. $y = -2^{x+2} + 1 = -4(2)^x + 1$ 31. $y = -2(2)^{-x} + 3$

33. $y = -2(3)^x + 7$ 35. $y = 2\left(\dfrac{1}{2}\right)^x - 4$

Section 4.3

1. $4^m = q$	3. $a^c = b$	5. $10^t = v$
7. $e^n = w$	9. $\log_4(y) = x$	11. $\log_c(k) = d$
13. $\log(b) = a$	15. $\ln(h) = k$	17. 9
19. 1/8	21. 1000	23. e^2
25. 2	27. -3	29. ½

31. 4   33. -3   35. -2

37. -1.398   39. 2.708   41. $\dfrac{\log(14)}{\log(5)} \approx 1.6397$

43. $\dfrac{\log\left(\dfrac{1}{15}\right)}{\log(7)} \approx -1.392$ 45. $\dfrac{\ln(17)}{5} \approx 0.567$ 47. $\dfrac{\dfrac{\log(38)}{\log(3)}+5}{4} \approx 2.078$

49. $\dfrac{\log(5)}{\log(1.03)} \approx 54.449$ 51. $\dfrac{\log\left(\dfrac{8}{3}\right)}{3\log(1.04)} \approx 8.335$ 53. $\dfrac{\ln\left(\dfrac{1}{5}\right)}{-0.12} \approx 13.412$

55. $\dfrac{\log\left(\dfrac{5}{8}\right)}{\log\left(\dfrac{1}{2}\right)} \approx 0.678$ 57. $f(t) = 300e^{-0.0943t}$ 59. $f(t) = 10e^{0.03922t}$

61. $f(t) = 150(1.0618)^t$ 63. $f(t) = 50(0.98807)^t$ 65. During the year 2013

67. During the year 2074   69. $\approx 34\, hours$ 71. 13.532 years

Section 4.4

1. $\log_3(4)$ 3. $\log_3(7)$ 5. $\log_3(5)$ 7. $\log_7(2)$ 9. $\log\left(6x^9\right)$

11. $\ln\left(2x^7\right)$ 13. $\log\left(x^2(x+1)^3\right)$ 15. $\dfrac{xz^3}{\sqrt{y}}$

17. $15\log(x)+13\log(y)-19\log(z)$ 19. $-2\ln(a)+4\ln(b)-5\ln(c)$

21. $\dfrac{3}{2}\log(x)-2\log(y)$ 23. $\ln(y)+\dfrac{1}{2}\left(\ln(y)-\ln(1-y)\right)$

25. $\dfrac{8}{3}\log(x)+\dfrac{14}{3}\log(y)$

27. $x \approx -0.717$ 29. $x \approx -6.395$ 31. $t \approx 17.329$

33. $x = \dfrac{2}{7}$ 35. $x \approx 0.123$ 37. $x \approx 4.642$

39. $x \approx 30.158$ 41. $x \approx -2.889$.   43. $x \approx 6.873$

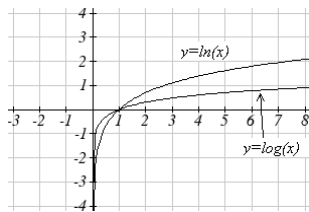45. $x = \dfrac{12}{11} \approx 1.091$ 47. $x = 10$

Section 4.5

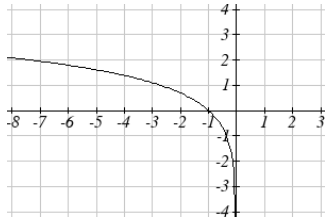1. Domain: $: x > 5$ V. A. @ $x = 5$
3. Domain: $x < 3$ V.A. @ $x = 3$
5. Domain: $x > -\dfrac{1}{3}$ V.A. @ $x = -\dfrac{1}{3}$
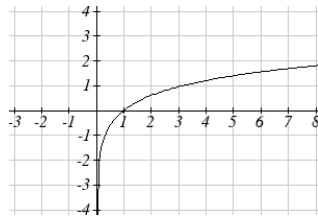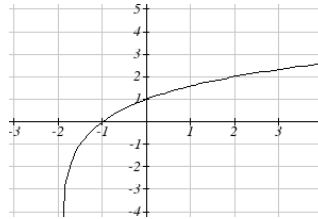
7. Domain: $x < 0$ V.A. @ $x = 0$

9.

11.

13.

15.

17. $y = \dfrac{1}{\log(2)}\log(-(x-1))$

19. $y = -\dfrac{3}{\log(3)}\log(x+4)$

21. $y = \dfrac{3}{\log(4)}\log(x+2)$

23. $y = -\dfrac{2}{\log(5)}\log(-(x-5))$

Section 4.6

1. $f(t) = 13(0.9195)^t$.   2 mg will remain after 22.3098 minutes

3. $f(t) = 200(0.999564)^t$. $f(1000) = 129.3311$ mg

5. $r = -0.06448$.   Initial mass: 9.9018 mg. After 3 days: 0.01648 mg

7. $f(t) = 250(0.9909)^t$.   Half-life $= 75.8653$ minutes

9. $f(t) = a(0.999879)^t$.   60% $(0.60a)$ would remain after 4222.813 years
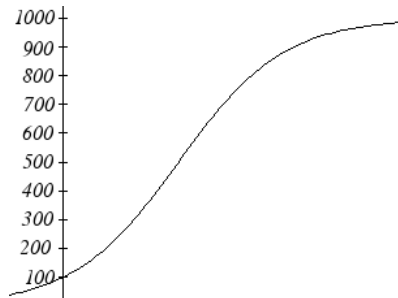
11. $P(t) = 1500(1.02337)^t$ (t in minutes). After 2 hours $= 24000$. After 100 minutes $=$ 15119

13. a) 610.5143 (about 611)   b) 25.6427 minutes   c) 10431.21   d) 106.9642 minutes
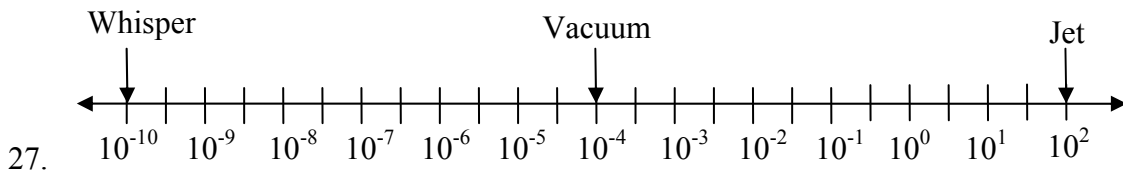
15. 23.1914 years

17. 53.319 hours

19. $T(t) = 90(0.99166)^t + 75$.   a) 134.212 deg   b) 112.743 minutes

21. a)   b) 100 c) 269.487 d) 7.324 years

23. $\log(x) = -0.5$. $x = 0.3162$ 25. $\log(x) = 1.5$. $x = 31.623$

27.

29. 63095.7 times more intense   31. MMS magnitude 5.817

33. a) about 1640671   b) 1.4 hours c) No, because $(2.042727)^{0.693147} \approx e^{0.495105}$
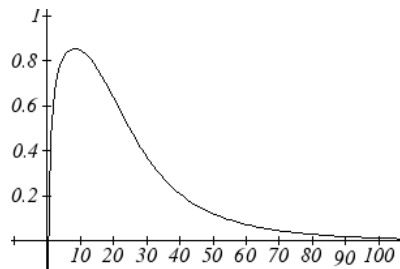
   d) Anja's data predicts a continuous growth rate of 0.4116, which is much smaller
   than the rate 0.495105 you calculated. Our model would overestimate the number of
   cells.

35. a) The curve that increases rapidly at first is $M(p)$

   b) $H(100) = 0.9775$

   c) Myoglobin: $M(20) = 0.9524$. Hemoglobin: $H(20) = 0.3242$

   d) At 20 torrs: 0.6282. At 40 torrs: 0.2060. At 60 torrs: 0.0714

 Efficiency seems to be maximized at about 8 torr

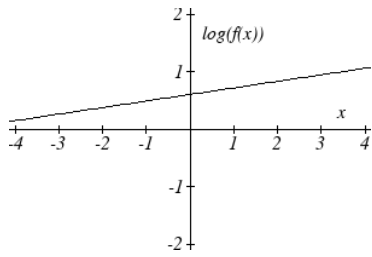37. a) $C(t) = 1.03526^t$, or $C(t) = e^{0.03466t}$

   b) Volume of one cell: $\frac{4}{3}\pi(50 \times 10^{-4})^3 \approx 5.236 \times 10^{-7}$ cm^3, so will need about

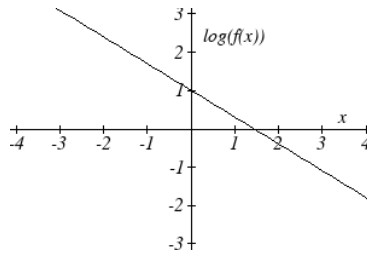 1.9099×10^6 cells for a volume of 1cm^3. $C(t) = 1.9099 \times 10^6$ after 417.3 hours

39. 31.699 days

Section 4.7

1. $\log(f(x)) = \log(1.3)x + \log(4)$

3. $\log(f(x)) = \log(0.2)x + 1$

5. $y = e^{\frac{1}{2}x-1} = e^{-1}e^{\frac{1}{2}x} \approx 0.368(1.6487)^x$

7. $y = 10^{-x-2} = 10^{-2}10^{-1x} = 0.01(0.1)^x$

9. $y = 776.682(1.426)^x$

11. $y = 548.51(1.195)^x$

13. expenditures are approximately \$205

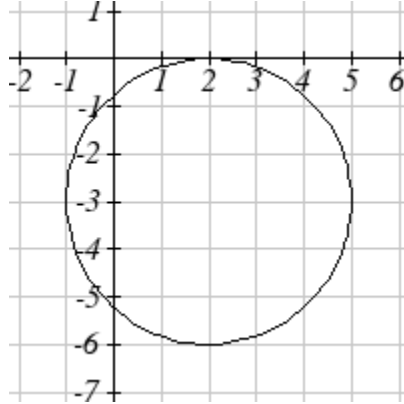15. $y = 7.599(1.016)^x$ $r = 0.83064$, $y = 0.1493x + 7.4893$, $r = 0.81713$. Using the better function, we predict electricity will be 11.157 cents per kwh

Chapter 5

Section 5.1

1. 10

3. $(x-8)^2 +(y+10)^2 =8^2$

5. $(x-7)^2 +(y+2)^2 =293$

7. $(x-5)^2 +(y-8)^2 =13$

9.

11. $(0,3+\sqrt{5})$ and $(0,3-\sqrt{5})$

13. (1.3416407865, 7.683281573)

15. (-1.07335, 2.8533)

17. 29.87 miles

Section 5.2

1.

3. π

5. 150°

7. 325°

9. 54°

11. $\dfrac{8\pi}{9}$

13. $\dfrac{\pi}{2}$

15. 35 miles

17. 8π cm
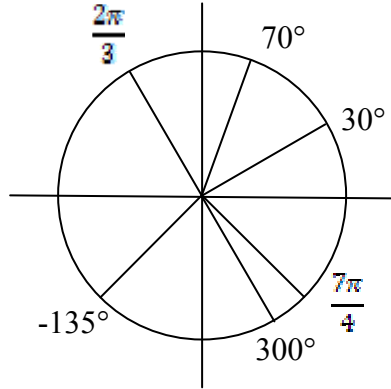
19. 5.7596 miles

21. 28.6479°

23. 14.1372 cm^2

25. 3960 rad/min   630.254 RPM

27. 2.094 in/sec, $\pi/12$ rad/sec, 2.5 RPM

29. 75,398.22 mm/min = 1.257 m/sec

31. Angular speed: $\pi/12$ rad/hr. Linear speed: 1036.73 miles/hr

Section 5.3

1. a. III   b. II

3. $-\dfrac{4}{5}$

5. $-\dfrac{4\sqrt{3}}{7}$

7. $-\dfrac{\sqrt{55}}{8}$

9. a. reference: 45°. Quadrant III. $\sin(225°) = -\dfrac{\sqrt{2}}{2}$. $\cos(225°) = -\dfrac{\sqrt{2}}{2}$

   b. reference: 60°. Quadrant IV. $\sin(300°) = -\dfrac{\sqrt{3}}{2}$. $\cos(300°) = \dfrac{1}{2}$

   c. reference: 45°. Quadrant II. $\sin(135°) = \dfrac{\sqrt{2}}{2}$. $\cos(135°) = -\dfrac{\sqrt{2}}{2}$

   d. reference: 30°. Quadrant III. $\sin(210°) = -\dfrac{1}{2}$. $\cos(210°) = -\dfrac{\sqrt{3}}{2}$

11. a. reference: $\dfrac{\pi}{4}$. Quadrant III. $\sin\left(\dfrac{5\pi}{4}\right) = -\dfrac{\sqrt{2}}{2}$. $\cos\left(\dfrac{5\pi}{4}\right) = -\dfrac{\sqrt{2}}{2}$

   b. reference: $\dfrac{\pi}{6}$. Quadrant III. $\sin\left(\dfrac{7\pi}{6}\right) = -\dfrac{1}{2}$. $\cos\left(\dfrac{7\pi}{6}\right) = -\dfrac{\sqrt{3}}{2}$

   c. reference: $\dfrac{\pi}{3}$. Quadrant IV. $\sin\left(\dfrac{5\pi}{3}\right) = -\dfrac{\sqrt{3}}{2}$. $\cos\left(\dfrac{5\pi}{3}\right) = \dfrac{1}{2}$

   d. reference: $\dfrac{\pi}{4}$. Quadrant II. $\sin\left(\dfrac{3\pi}{4}\right) = \dfrac{\sqrt{2}}{2}$. $\cos\left(\dfrac{3\pi}{4}\right) = -\dfrac{\sqrt{2}}{2}$

13. a. $\sin\left(-\dfrac{3\pi}{4}\right) = -\dfrac{\sqrt{2}}{2}$ $\cos\left(-\dfrac{3\pi}{4}\right) = -\dfrac{\sqrt{2}}{2}$

   b. $\sin\left(\dfrac{23\pi}{6}\right) = -\dfrac{1}{2}$ $\cos\left(\dfrac{23\pi}{6}\right) = \dfrac{\sqrt{3}}{2}$

   c. $\sin\left(-\dfrac{\pi}{2}\right) = -1$ $\cos\left(-\dfrac{\pi}{2}\right) = 0$

   d. $\sin(5\pi) = 0$ $\cos(5\pi) = -1$

15. a. $\dfrac{2\pi}{3}$ b. 100°   c. 40°   d. $\dfrac{5\pi}{3}$ e. 235°

17. a. $\dfrac{5\pi}{3}$ b. 280°   c. 220°   d. $\dfrac{2\pi}{3}$ e. 55°

19. (-11.491, -9.642)

Section 5.4

1. $\sec(\theta) = \sqrt{2}$, $\csc(\theta) = \sqrt{2}$, $\tan(\theta) = 1$, $\cot(\theta) = 1$

3. $\sec(\theta) = -\dfrac{2\sqrt{3}}{3}$, $\csc(\theta) = 2$, $\tan(\theta) = -\dfrac{\sqrt{3}}{3}$, $\cot(\theta) = -\sqrt{3}$

5. $\sec(\theta) = -2$, $\csc(\theta) = \dfrac{2\sqrt{3}}{3}$, $\tan(\theta) = -\sqrt{3}$, $\cot(\theta) = -\dfrac{\sqrt{3}}{3}$

7. a. $\sec(135°) = -\sqrt{2}$ b. $\csc(210°) = -2$ c. $\tan(60°) = \sqrt{3}$.   d. $\cot(225°) = 1$

9. $\cos(\theta) = -\dfrac{\sqrt{7}}{4}$, $\sec(\theta) = -\dfrac{4\sqrt{7}}{7}$, $\csc(\theta) = \dfrac{4}{3}$, $\tan(\theta) = -\dfrac{3\sqrt{7}}{7}$, $\cot(\theta) = -\dfrac{\sqrt{7}}{3}$

. $\sin(\theta) = -\dfrac{2\sqrt{2}}{3}$, $\sec(\theta) = -\dfrac{3\sqrt{2}}{4}$, $\csc(\theta) = -3$, $\tan(\theta) = 2\sqrt{2}$, $\cot(\theta) = \dfrac{\sqrt{2}}{4}$

13. $\sin(\theta) = \dfrac{12}{13}$, $\cos(\theta) = \dfrac{5}{13}$, $\sec(\theta) = \dfrac{13}{5}$, $\csc(\theta) = \dfrac{13}{12}$, $\cot(\theta) = \dfrac{5}{12}$

15. a. $\sin(0.15) = 0.1494$ $\cos(0.15) = 0.9888$ $\tan(0.15) = 0.1511$
    b. $\sin(4) = -0.7568$ $\cos(4) = -0.6536$ $\tan(4) = 1.1578$
    c. $\sin(70°) = 0.9397$ $\cos(70°) = 0.3420$ $\tan(70°) = 2.7475$
    d. $\sin(283°) = -0.9744$ $\cos(283°) = 0.2250$ $\tan(283°) = -4.3315$

17. $\sec(t)$ 19. $\tan(t)$ 21. $\tan(t)$ 23. $\cot(t)$ 25. $\left(\sec(t)\right)^2$

Section 5.5

1. $\sin(A) = \dfrac{5\sqrt{41}}{41}, \cos(A) = \dfrac{4\sqrt{41}}{41}, \tan(A) = \dfrac{5}{4}$

$\sec(A) = \dfrac{\sqrt{41}}{5}, \csc(A) = \dfrac{\sqrt{41}}{4}, \cot(A) = \dfrac{4}{5}$

3. $c = 14$, $b = 7\sqrt{3}$, $B = 60°$ 5. $a = 5.3171$, $c = 11.3257$, $A = 28°$

7. $a = 9.0631$, $b = 4.2262$, $B = 25°$ 9. 32.4987 ft
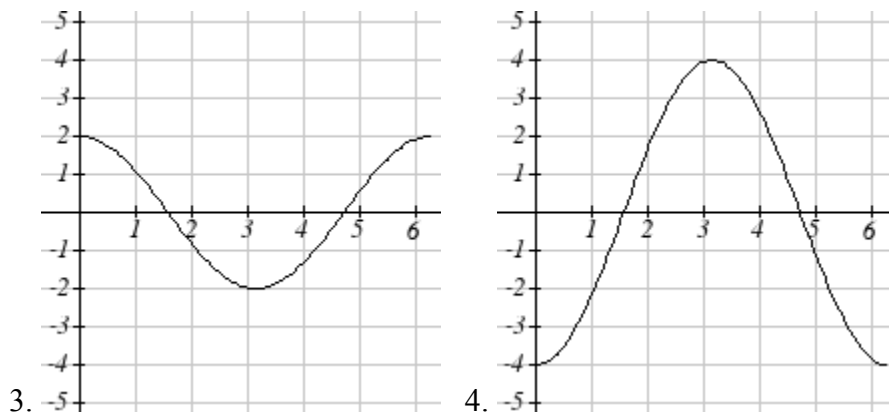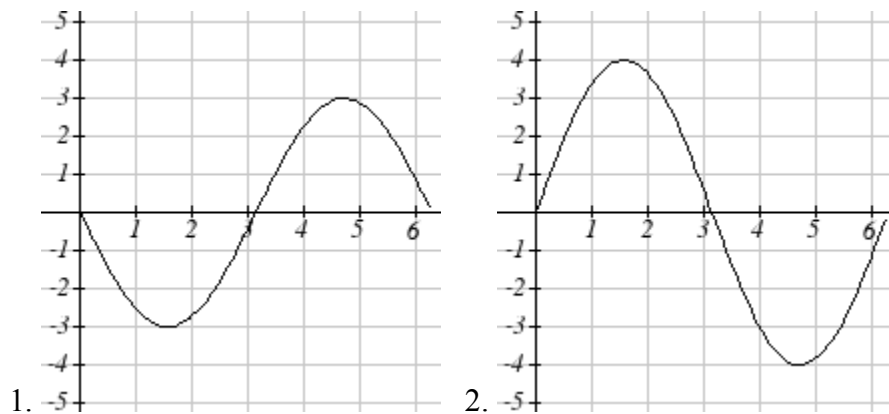
11. 836.2698 ft   13. 460.4069 ft

15. 660.35 feet   17. 28.025 ft

19. 143.0427   21. 86.6685

Chapter 6

Section 6.1

1.

2.

3.

4.

5. Amp: 3. Period= 2. Midline: y= -4. $f(t) = 3\sin(\pi t) - 4$

6. Amp: 2. Period= 4. Midline: y= -3. $f(t) = 2\sin\left(\dfrac{\pi}{2}t\right) - 3$

7. Amp: 2. Period= 4π. Midline: y= 1. $f(t) = 2\cos\left(\dfrac{1}{2}t\right) + 1$

8. Amp: 3. Period= π. Midline: y= -1. $f(t) = 3\cos(2t) - 1$

9. Amp: 2. Period= 5. Midline: y= 3. $f(t) = -2\cos\left(\dfrac{2\pi}{5}t\right) + 3$

10. Amp: 1. Period= 3. Midline: y= -1. $f(t) = -\sin\left(\dfrac{2\pi}{3}t\right) - 1$

11. Amp: 3, Period = $\dfrac{\pi}{4}$, Shift: 4 left, Midline: $y = 5$

12. Amp: 4, Period = 4, Shift: 3 right, Midline: $y = 7$

13. Amp: 2, Period = $\dfrac{2\pi}{3}$, Shift: 7 right, Midline: $y = 4$

14. Amp: 5, Period $= \dfrac{2\pi}{5}$, Shift: 4 left, Midline: $y = -2$

15. Amp: 1, Period $= 12$, Shift: 6 left, Midline: $y = -3$

16. Amp: 8, Period $= \dfrac{12}{7}$, Shift: 3 left, Midline: $y = 6$

17. $f(x) = 4\sin\left(\dfrac{\pi}{5}(x+1)\right)$

18. $f(x) = 3\sin\left(\dfrac{\pi}{3}(x+1)\right)$

19. $f(x) = \cos\left(\dfrac{\pi}{5}(x+2)\right)$

20. $f(x) = -2\cos\left(\dfrac{\pi}{3}(x-1)\right)$

21. $D(t) = 50 - 7\sin\left(\dfrac{\pi}{12}t\right)$

22. $D(t) = 68 - 12\sin\left(\dfrac{\pi}{12}t\right)$

23. a. Amp: 12.5. Midline: $y = 13.5$. Period: 10

    b. $h(t) = -12.5\cos\left(\dfrac{\pi}{5}t\right) + 13.5$

    c. $h(5) = 26$ meters

24. a. Amp: 17.5. Midline: $y = 20.5$. Period: 8

    b. $h(t) = -17.5\cos\left(\dfrac{\pi}{8}t\right) + 20.5$
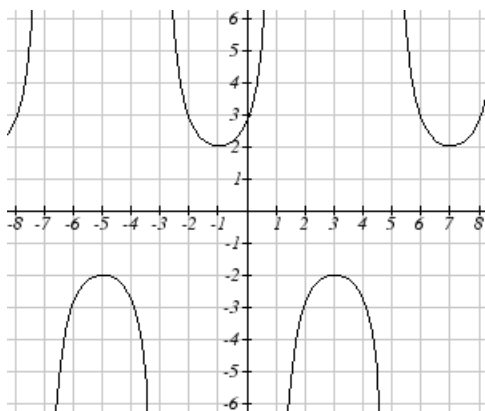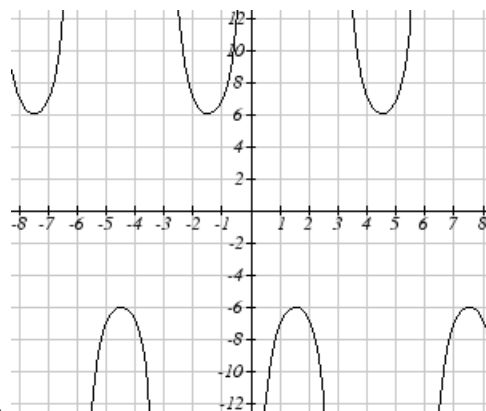
    c. $h(4) = 38$ meters

Section 6.2

1. II

3. I

5. Period: $\dfrac{\pi}{4}$. Horizontal shift: 8 right
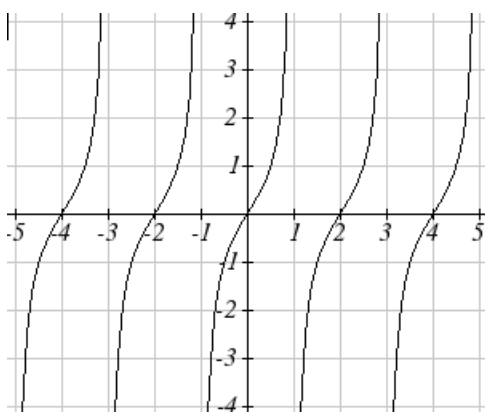
7. Period: 8. Horizontal shift: 1 left

9. Period: 6. Horizontal shift: 3 left

160

11.

13.

15.

17. $f(x) = 2\sec\left(\dfrac{\pi}{2}x\right) - 1$

19. $f(x) = 2\csc\left(\dfrac{\pi}{4}x\right) + 1$

21. $\tan(-x) = 1.5$

23. $\sec(-x) = 2$

25. $\csc(-x) = 5$

27. $-\csc(x)$

Section 6.3

1. $\dfrac{\pi}{4}$

3. $-\dfrac{\pi}{6}$

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

7. $\dfrac{3\pi}{4}$

9. $\dfrac{\pi}{4}$

11. $-\dfrac{\pi}{3}$

13. 1.9823

15. -0.9273

17. 44.427°

19. $\dfrac{\pi}{4}$

21. $-\dfrac{\pi}{6}$

23. $\dfrac{2\sqrt{10}}{7}$

25. $\dfrac{1}{\sqrt{17}}$

27. $\dfrac{\sqrt{25 - x^2}}{5}$

29. $\dfrac{3x}{\sqrt{9x^2 + 1}}$

Section 6.4

1. $\dfrac{5\pi}{4}, \dfrac{7\pi}{4}$ 3. $\dfrac{\pi}{3}, \dfrac{5\pi}{3}$ 5. $\dfrac{\pi}{2}$ 7. $\dfrac{\pi}{2}, \dfrac{3\pi}{2}$

9. $\dfrac{\pi}{4} + 2\pi k, \dfrac{7\pi}{4} + 2\pi k$, where k is an integer

11. $\dfrac{7\pi}{6} + 2\pi k, \dfrac{11\pi}{6} + 2\pi k$, where k is an integer

13. $\dfrac{\pi}{18} + \dfrac{2\pi}{3}k, \dfrac{5\pi}{18} + \dfrac{2\pi}{3}k$, where k is an integer

15. $\dfrac{5\pi}{12} + \dfrac{2\pi}{3}k, \dfrac{7\pi}{12} + \dfrac{2\pi}{3}k$, where k is an integer

17. $\dfrac{\pi}{6} + \pi k, \dfrac{5\pi}{6} + \pi k$, where k is an integer

19. $\dfrac{\pi}{4} + \dfrac{2\pi}{3}k, \dfrac{5\pi}{12} + \dfrac{2\pi}{3}k$, where k is an integer

21. $4 + 8k$, where k is an integer

23. $\dfrac{1}{6} + 2k, \dfrac{5}{6} + 2k$, where k is an integer

25. 0.2734, 2.8682   27. 3.7603, 5.6645   29. 2.1532, 4.1300
31. 0.7813, 5.5019   33. 0.04829, 0.47531   35. 0.7381, 1.3563
37. 0.9291, 3.0709   39. 1.3077, 4.6923

Section 6.5

1. $c = \sqrt{89}$, $A = 57.9946°$, $B = 32.0054°$

3. $b = \sqrt{176}$, $A = 27.8181°$, $B = 62.1819°$

5. $y(x) = 6\sin\left(\dfrac{\pi}{2}(x-1)\right) + 4$

7. $D(t) = 50 - 13\cos\left(\dfrac{\pi}{12}(t-5)\right)$

9. a. $P(t) = 129 - 25\cos\left(\dfrac{\pi}{6}t\right)$ b. $P(t) = 129 - 25\cos\left(\dfrac{\pi}{6}(t-3)\right)$

11. 75 degrees

13. 8

15. 2.80869431742

17. 5.035 months

Chapter 7

Section 7.1

1. $\dfrac{7\pi}{6}, \dfrac{11\pi}{6}$

3. $\dfrac{\pi}{3}, \dfrac{5\pi}{3}$

5. $\dfrac{2}{3}+8k$, and $\dfrac{10}{3}+8k$, where k is an integer

7. $\dfrac{5\pi}{12}+k\pi$ and $\dfrac{7\pi}{12}+k\pi$, where k is an integer

9. $0.1339+10k$ and $8.6614+10k$, where k is an integer

11. $1.1438+\dfrac{2\pi}{3}k$ and $1.9978+\dfrac{2\pi}{3}k$, where k is an integer

13. $\dfrac{\pi}{2}, \dfrac{3\pi}{2}, 0.644, 2.498$

15. $0.056, 1.515, 3.197, 4.647$

17. $0, \pi, \dfrac{\pi}{3}, \dfrac{5\pi}{3}$

19. $\dfrac{\pi}{6}, \dfrac{5\pi}{6}, \dfrac{7\pi}{6}, \dfrac{11\pi}{6}$

21. $1.183, 1.958, 4.325, 5.100$

23. $\dfrac{3\pi}{2}, \dfrac{7\pi}{6}, \dfrac{11\pi}{6}$

25. $\pi, \dfrac{\pi}{3}, \dfrac{5\pi}{3}$

27. $1.823, 4.460$

29. $2.301, 3.983, 0.723, 5.560$

31. $3.305, 6.120$

33. $0, \dfrac{\pi}{3}, \dfrac{2\pi}{3}, \pi, \dfrac{4\pi}{3}, \dfrac{5\pi}{3}$

35. $0, \dfrac{\pi}{4}, \dfrac{3\pi}{4}, \pi, \dfrac{5\pi}{4}, \dfrac{7\pi}{4}$

37. $\dfrac{\pi}{6}, \dfrac{\pi}{3}, \dfrac{5\pi}{6}, \dfrac{4\pi}{3}$

39. $0, \pi, 1.231, 5.052$

41. $\dfrac{\pi}{3}, \dfrac{5\pi}{3}$

Section 7.2

1. $\dfrac{\sqrt{2}+\sqrt{6}}{4}$

3. $\dfrac{-\sqrt{2}-\sqrt{6}}{4}$

5. $\dfrac{\sqrt{2}-\sqrt{6}}{4}$

7. $\dfrac{\sqrt{2}+\sqrt{6}}{4}$

9. $\dfrac{\sqrt{3}}{2}\sin(x)-\dfrac{1}{2}\cos(x)$

11. $-\dfrac{\sqrt{3}}{2}\cos(x)+\dfrac{1}{2}\sin(x)$

13. $\sec(t)$

15. $\tan(x)$

17. $8\big(\cos(5x)-\cos(27x)\big)$

19. $\sin(8x)+\sin(2x)$

21. $2\cos(5t)\cos(t)$

23. $2\sin(5x)\cos(2x)$

25. a. $\left(\dfrac{2}{3}\right)\left(-\dfrac{1}{4}\right)+\left(-\dfrac{\sqrt{5}}{3}\right)\left(\dfrac{\sqrt{15}}{4}\right)=\dfrac{-2-5\sqrt{3}}{12}$

b. $\left(-\dfrac{\sqrt{5}}{3}\right)\left(-\dfrac{1}{4}\right)+\left(\dfrac{2}{3}\right)\left(\dfrac{\sqrt{15}}{4}\right)=\dfrac{\sqrt{5}+2\sqrt{15}}{12}$

27. $0.373+\dfrac{2\pi}{3}k$ and $0.674+\dfrac{2\pi}{3}k$, where k is an integer

29. $2\pi k$, where k is an integer

31. $\dfrac{\pi}{7}+\dfrac{4\pi}{7}k$, $\dfrac{3\pi}{7}+\dfrac{4\pi}{7}k$, $\dfrac{\pi}{3}+\dfrac{4\pi}{3}k$, and $\pi+\dfrac{4\pi}{3}k$, where k is an integer

33. $\dfrac{7\pi}{12}+\pi k$, $\dfrac{11\pi}{12}+\pi k$, and $\dfrac{\pi}{4}k$, where k is an integer

35. $2\sqrt{13}\sin(x+5.3004)$ or $2\sqrt{13}\sin(x-0.9828)$

37. $\sqrt{29}\sin(3x+0.3805)$

39. $0.3681, 3.8544$

41. $0.7854, 1.8158$

43. $\tan(6t)$

Section 7.3

1. a. $\dfrac{3\sqrt{7}}{32}$ b. $\dfrac{31}{32}$ c. $\dfrac{3\sqrt{7}}{31}$

3. $\cos(56°)$

5. $\cos(34°)$

7. $\cos(18x)$

9. $2\sin(16x)$

11. $0,\pi,2.4189,3.8643$

13. $0.7297, 2.4119, 3.8713, 5.5535$

15. $\dfrac{\pi}{6}, \dfrac{\pi}{2}, \dfrac{5\pi}{6}, \dfrac{3\pi}{2}$

17. a. $\dfrac{2\pi}{9}, \dfrac{4\pi}{9}, \dfrac{8\pi}{9}, \dfrac{10\pi}{9}, \dfrac{14\pi}{9}, \dfrac{16\pi}{9}, 0, \dfrac{2\pi}{3}, \dfrac{4\pi}{93}$

19. $\dfrac{1+\cos(10x)}{2}$

21. $\dfrac{3}{8} - \dfrac{1}{2}\cos(16x) - \dfrac{1}{8}\cos(32x)$

23. $\dfrac{1}{16} - \dfrac{1}{16}\cos(2x) + \dfrac{1}{16}\cos(4x) - \dfrac{1}{16}\cos(2x)\cos(4x)$

25. a. $\sqrt{\dfrac{1}{2} + \dfrac{2\sqrt{3}}{7}}$ b. $\sqrt{\dfrac{1}{2} - \dfrac{2\sqrt{3}}{7}}$ c. $\dfrac{1}{7-4\sqrt{3}}$

Section 7.4

1. $y = 3\sin\left(\dfrac{\pi}{6}(x-3)\right) - 1$

3. Amplitude: 8, Period: $\dfrac{1}{3}$ second, Frequency: 3 Hz (cycles per second)

5. $P(t) = -19\cos\left(\dfrac{\pi}{6}t\right) + \dfrac{40}{3}t + 650$ 7. $P(t) = -33\cos\left(\dfrac{\pi}{6}t\right) + 900(1.07)^t$

9. $D(t) = 10(0.85)^t \cos(36\pi t)$ 11. $D(t) = 17(0.9145)^t \cos(28\pi t)$

13. a. IV   b. III   15. $y = 6(4)^x + 5\sin\left(\dfrac{\pi}{2}x\right)$

17. $y = -3\sin\left(\dfrac{\pi}{2}\right) + 2x + 7$ 19. $y = 8\left(\dfrac{1}{2}\right)^x \cos\left(\dfrac{\pi}{2}x\right) + 3$
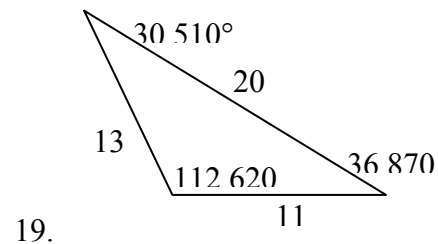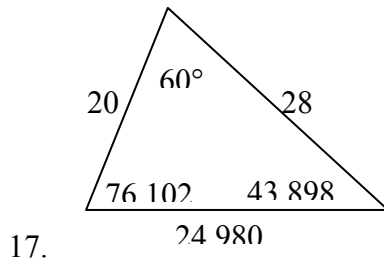
Chapter 8

Section 8.1

1.

3.

5.

7.
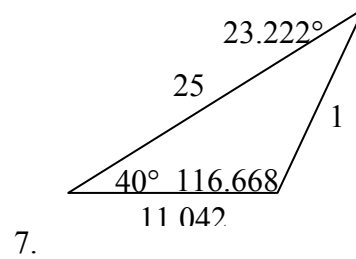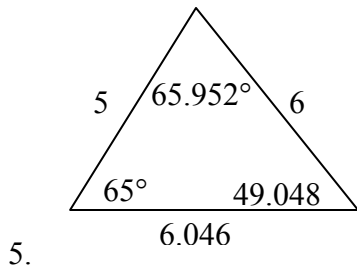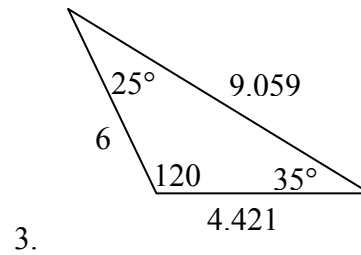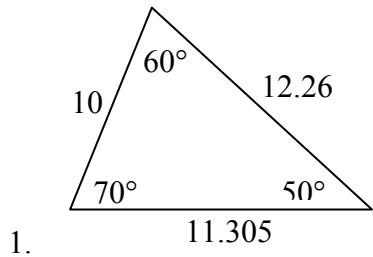
9. B= 68, a = 14.711, c = 20.138

11. B = 28.096, C = 32.904, c = 16.149

13. Not possible.

15. B = 64.243, C = 72.657, c = 257.328 OR B=115.757, C= 21.143, c = 97.238

17.

19.

21. $c = 2.066, \angle A = 52.545°, \angle B = 86.255°$

23. $a = 11.269, \angle B = 27.457°, \angle C = 32.543°$

25. 177.562

27. 978.515 ft

29. Distance to A: 565.258 ft. Distance to shore: 531.169 ft

31. 529.014 m

33. 173.877 feet

35. 4.642 km, 2.794 km

37. 757.963 ft

39. 2371.129 miles

41. 65.375 cm^2

43. 14.182

Section 8.2

1. $\left(-\dfrac{7\sqrt{3}}{2}, -\dfrac{7}{2}\right)$
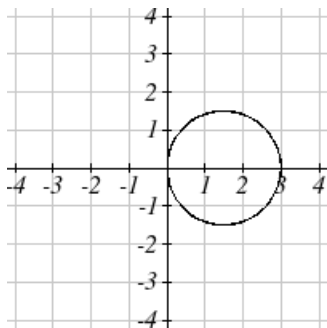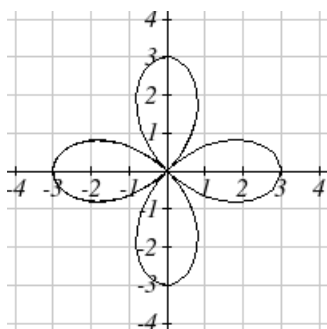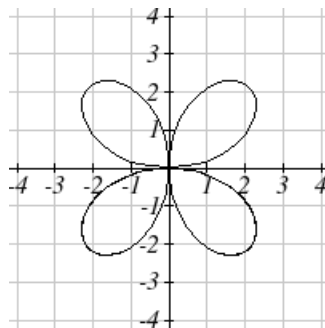
3. $\left(2\sqrt{2}, -2\sqrt{2}\right)$

5. $\left(3\sqrt{2}, -3\sqrt{2}\right)$

7. $(0,3)$

9. $\left(-\dfrac{3\sqrt{3}}{2}, -\dfrac{3}{2}\right)$

11. $(-1.248, 2.728)$

13. $\left(2\sqrt{5}, 0.464\right)$

15. $\left(2\sqrt{13}, 2.159\right)$

17. $\left(\sqrt{34}, 5.253\right)$

19. $\left(\sqrt{269}, 4.057\right)$

21. $r = 3\sec(\theta)$

23. $r = \dfrac{\sin(\theta)}{4\cos^2(\theta)}$

25. $r = 4\sin(\theta)$

27. $r = \dfrac{\cos(\theta)}{\left(\cos^2(\theta) - \sin^2(\theta)\right)}$

29. $x^2 + y^2 = 3y$

31. $y + 7x = 4$

33. $x = 2$

35. $x^2 + y^2 = x + 2$

37. A   39. C   41. E   43. C   45. D   47. F

49.   51.   53.

55.   57.   59.

61.

63.

65.

Section 8.3

1. $3i$

3. -12

5. $1+\sqrt{3}i$

7. $8-i$

9. $-11+4i$

11. $-12+8i$

13. $30-10i$

15. $11+10i$

17. 20

19. $\dfrac{3}{2}+2i$

21. $\dfrac{3}{2}+\dfrac{5}{2}i$

23. $-\dfrac{1}{25}-\dfrac{18}{25}i$

25. -1

27. i
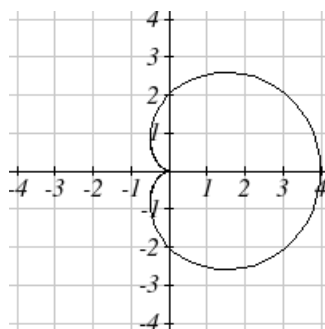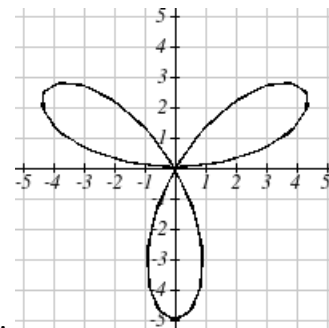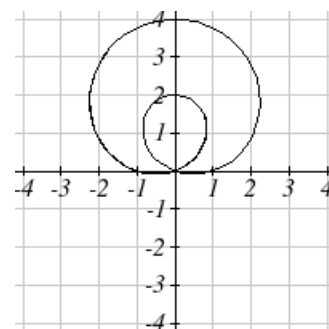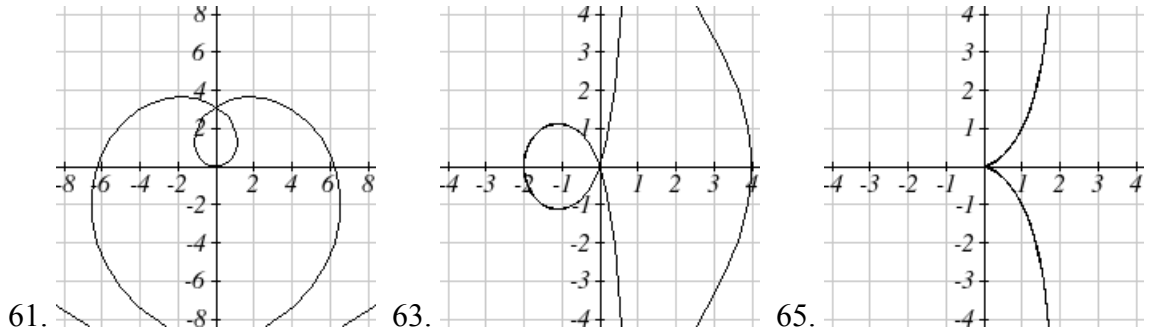
29. $3\cos(2)+3\sin(2)i = -1.248+2.728i$

31. $3\sqrt{3}+3i$

33. $-\dfrac{3\sqrt{2}}{2}-\dfrac{3\sqrt{2}}{2}i$

35. $6e^{0i}$

37. $4e^{\frac{3\pi}{2}i}$

39. $2\sqrt{2}e^{\frac{\pi}{4}i}$

41. $3\sqrt{2}e^{\frac{3\pi}{4}i}$

43. $\sqrt{34}e^{0.540i}$

45. $\sqrt{10}e^{2.820i}$

47. $\sqrt{17}e^{4.467i}$

49. $\sqrt{26}e^{6.086i}$

51. $6e^{\frac{5\pi}{12}i}$

53. $2e^{\frac{7\pi}{12}i}$

55. $1024e^{\frac{5\pi}{2}i}$

57. $4e^{\frac{\pi}{3}i}$

59. 4096

61. $0.788+1.903i$

63. $1.771+0.322i$

65. $\sqrt{2}, 0.408+1.255i, -1.068+0.776i, -1.068-0.776i, 0.408-1.255i$

67. $1, \dfrac{1}{2}+\dfrac{\sqrt{3}}{2}i, -\dfrac{1}{2}+\dfrac{\sqrt{3}}{2}i, -1, -\dfrac{1}{2}-\dfrac{\sqrt{3}}{2}i, \dfrac{1}{2}-\dfrac{\sqrt{3}}{2}i$

Section 8.4

1. $-4,2$
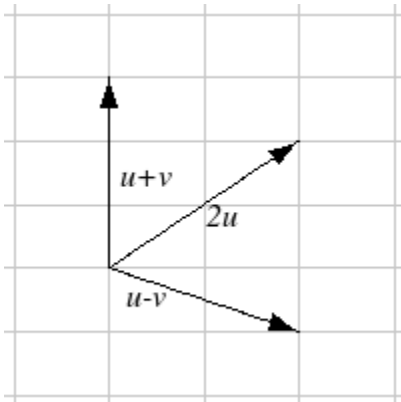
3. The vectors do not need to start at the same point

5. $3\vec{v} - \vec{u}$ 7. $3\sqrt{2}, 3\sqrt{2}$

9. $-6.128, -5.142$ 11. Magnitude: 4, Direction: 90°

13. Magnitude: 7.810, Direction: 39.806°

15. Magnitude: 2.236, Direction: 153.435°

17. Magnitude: 5.385, Direction: 291.801°

19. Magnitude: 7.211, Direction: 236.310°

21. $\vec{u} + \vec{v} = \langle 3,2 \rangle$, $\vec{u} - \vec{v} = \langle 1,-8 \rangle$, $2\vec{u} - 3\vec{v} = \langle 1,-21 \rangle$

23. 4.635 miles, 17.764 deg N of E

25. 17 miles. 10.318 miles

27. $\overrightarrow{F_{net}} = -4, -11$

29. Distance: 2.868. Direction: 86.474° North of West, or 3.526° West of North

31. 4.924 degrees. 659 km/hr
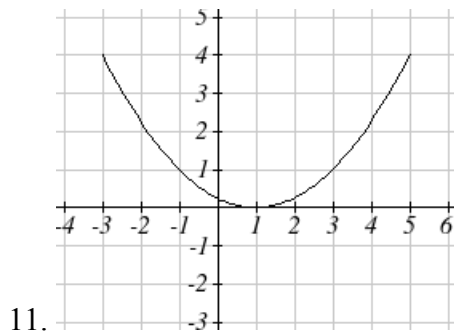
33. 4.424 degrees

35. (0.081, 8.602)

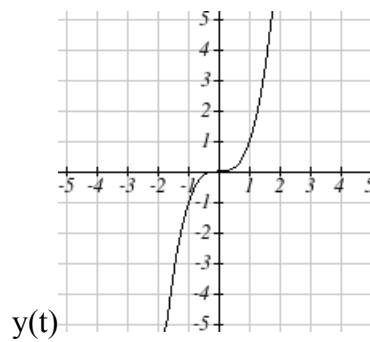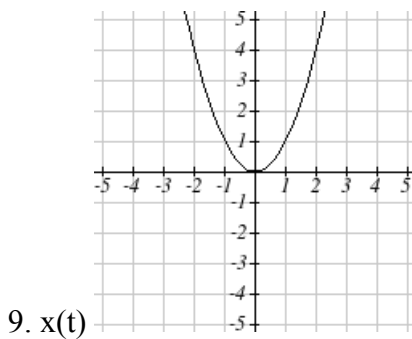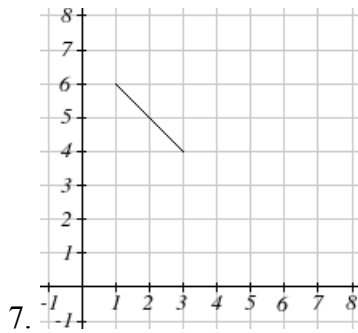37. 21.801 degrees, relative to the car's forward direction

Section 8.5

1. C   3. E   5. F

7.

9. x(t)   y(t)

11.

13. $y = -2 + 2x$

15. $y = 3\sqrt{\dfrac{x-1}{2}}$

17. $x = 2e^{\frac{1-y}{5}}$ or $y = 1 - 5\ln\left(\dfrac{x}{2}\right)$

19. $x = \left(\dfrac{y}{2}\right)^3 - \dfrac{y}{2}$

21. $y = x^3$

23. $\left(\dfrac{x}{4}\right)^2 + \left(\dfrac{y}{5}\right)^2 = 1$

25. $\begin{cases} x(t) = t \\ y(t) = 3t^2 + 3 \end{cases}$

27. $\begin{cases} x(t) = 3\log(t) + t \\ y(t) = t \end{cases}$.

29. $\begin{cases} x(t) = 2\cos(t) \\ y(t) = 3\sin(t) \end{cases}$

31. $\begin{cases} x(t) = t^3 \\ y(t) = t + 2 \end{cases}$

33. $\begin{cases} x(t) = t - 1 \\ y(t) = -t^2 \end{cases}$

35. $\begin{cases} x(t) = -2 + 3t \\ y(t) = 5 - 2t \end{cases}$

37. $\begin{cases} x(t) = 4\cos(3t) \\ y(t) = 6\sin(t) \end{cases}$

39. $\begin{cases} x(t) = 4\cos(2t) \\ y(t) = 3\sin(3t) \end{cases}$

41. $y(x) = -16\left(\dfrac{x}{15}\right)^2 + 20\left(\dfrac{x}{15}\right)$

43. $\begin{cases} x(t) = 20\sin\left(\dfrac{2\pi}{5}t\right) + 8\sin(\pi t) \\ y(t) = 35 - 20\cos\left(\dfrac{2\pi}{5}t\right) - 8\cos(\pi t) \end{cases}$