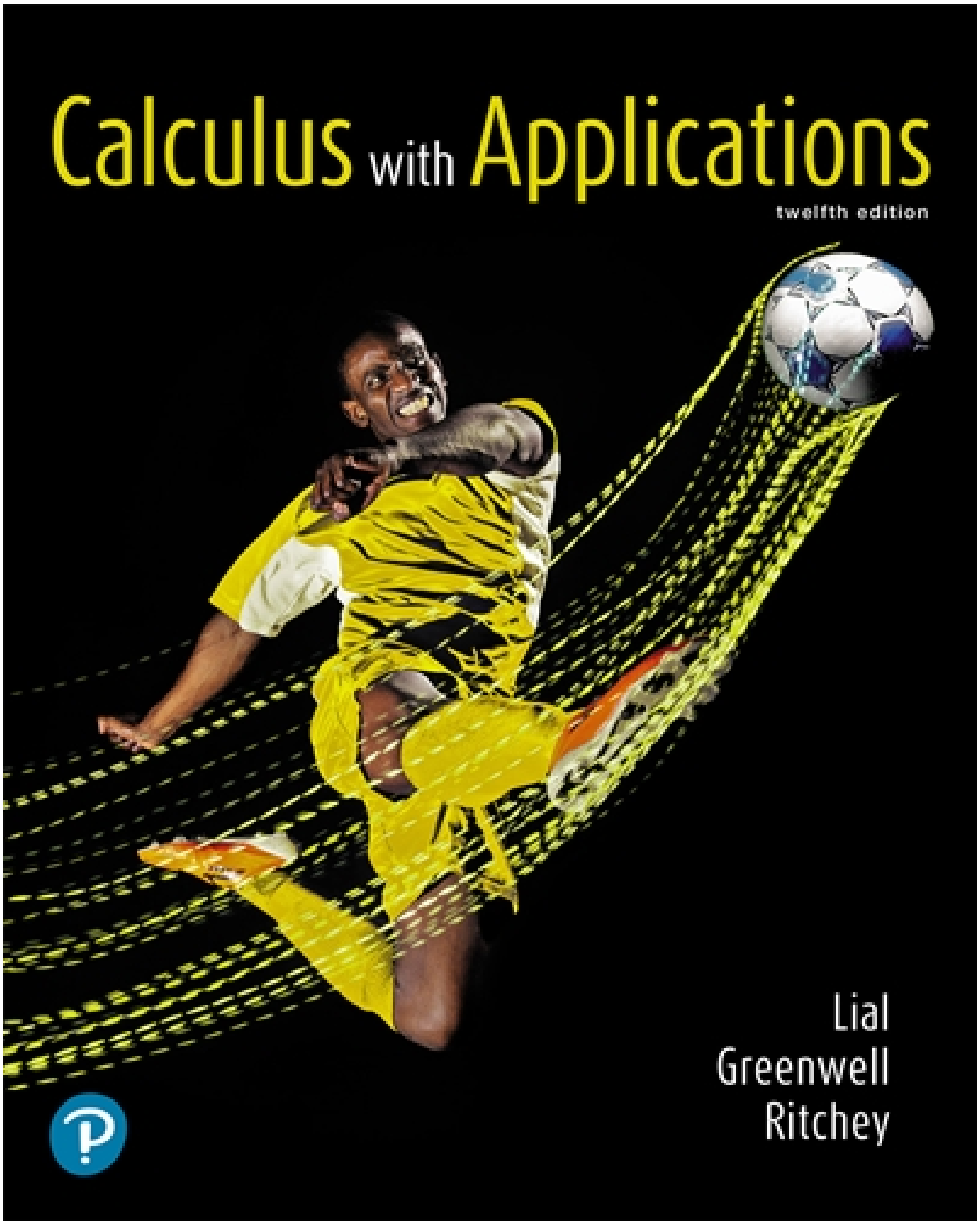
Solutions for Calculus with Applications 12th Edition by Lial



Solutions

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PREFACE

This book provides several resources for instructors using *Calculus with Applications*, Twelfth Edition, by Margaret L. Lial, Raymond N. Greenwell, and Nathan P. Ritchey, with Katherine Ritchey, Sarah Ritchey Patterson, and Blain Patterson.

- Hints for teaching *Calculus with Applications* are provided as a resource for faculty.
- One open-response form and one multiple-choice form of a pretest are provided. These tests are an aid to instructors in identifying students who may need assistance.
- One open-response form and one multiple-choice form of a final examination are provided.
- Solutions for nearly all of the exercises in the textbook are included. Solutions are usually not provided for exercises with open-response answers.

HINTS FOR TEACHING CALCULUS WITH APPLICATIONS

Algebra Reference

Some instructors obtain best results by going through this chapter carefully at the beginning of the semester. Others find it better to refer to it as needed throughout the course. Use whichever method works best for your students. As in the previous edition, we refer to the chapter as a "Reference" rather than a "Review," and the regular page numbers don't begin until Chapter 1. We hope this will make your students less anxious if you don't cover this material.

Chapter 1

Instructors sometimes go to either of two extremes in this chapter and the next. Some feel that their students have already covered enough precalculus in high school or in previous courses, and consequently begin with Chapter 3. Unfortunately, if they are wrong, their students may do poorly. Other instructors spend at least half a semester on Chapters 1 and 2 and the algebra reference chapter, and subsequently have little time for calculus. Such a course should not be labeled as calculus. We recommend trying to strike a balance, which may still not make all your students happy. A few may complain that the review of algebra, functions, and graphs is too quick; such students should be sent to a more basic course. Those students who are familiar with this material may become lazy and develop habits that will hurt them later in the course. You may wish to assign a few challenging exercises to keep these students on their toes.

Chapter 1 of *Calculus with Applications* is identical to Chapter 1 of *Finite Mathematics* and may be skipped by students who have already taken a course using that text. In this edition, we have streamlined the chapter from four to three sections, allowing instructors to reach the calculus material more quickly.

Section 1.1

This section and the next may seem fairly basic to students who covered linear functions in high school. Nevertheless, many students who have graphed hundreds of lines in their lifetime still lack a thorough understanding of slope, which hampers their understanding of the derivative. Such students could benefit from doing dozens of exercises similar to 43–46.

Perpendicular lines are not used in future chapters and could be skipped if you are in a hurry.

Section 1.2

Much recent research has been devoted to students' misunderstandings of the function concept. Such misunderstandings are among the major impediments to learning calculus. One way to help students is to study a simple class of functions first, as we do in this section. In this edition, even more of the general material on functions, including domain and range, is postponed until Chapter 2.

Supply and demand provides the students' first experience with a mathematical model. Spend time developing both the economics and the mathematics involved.

Stress that for cost, revenue, and profit functions, x represents the number of units. For supply and demand functions, we use the economists' notation of q to represent the number of units.

Emphasize the difference between the profit earned on 100 units sold as opposed to the number of units that must be sold to produce a profit of $100.

Section 1.3

The statistical functions on a calculator can greatly simplify these calculations, allowing more time for discussion and further examples. In this edition, we use "parallel presentation" to allow the instructor a choice on the extent technology is used. This section may be skipped if you are in a hurry, but your students can benefit from the realistic model and the additional work with equations of lines.

Section 2.1

After learning about linear functions in the previous chapter, students now learn about functions in general. This concept is critical for success in calculus. Unless sufficient time is devoted to this section, the results will become apparent later when students don't understand the derivative. One device that helps students distinguish $f(x+h)$ from $f(x)+h$ is to use a box in place of the letter x, as we do in this section before Example 6.

Section 2.2

This section combines the topics of quadratic functions and translation and reflection, with a minimal amount of material on completing the square. Our experience is that students graph quadratics most easily by first finding the y-intercept, then finding the x-intercepts when they exist (using factoring or the quadratic formula), and finding the vertex last by locating the point midway between the x-intercepts or, if the quadratic formula was used, by letting $x=-b/(2a)$.

Quadratics are among a small group of functions that can be analyzed completely with ease, so they are used throughout the text. On the other hand, the advent of graphing calculators has made ease of graphing less important, so we rely on quadratics less than in previous editions.

Some instructors pressed for time may choose to skip translations and reflections. But we have found that students who understand that the graph of $f(x)=5-\sqrt{4-x}$ is essentially the same as the graph of $f(x)=\sqrt{x}$, just shifted and reflected, will have an easier time when using the derivative to graph functions. Since students are familiar with very few classes of functions at this point, it helps to work with functions defined solely by their graphs, such as Exercises 35–38.

Exercises 43–50 cover stretching and shrinking of graphs in the vertical and horizontal directions. Covering these exercises carefully will not only give students a better grasp of functions, but will help them later to interpret the chain rule.

Section 2.3

Graphing calculators have made point plotting of functions less important than before. Plotting points by hand should not be entirely neglected, however, because a small amount is helpful when using the derivative to graph functions.

The two main goals of this section are to have an understanding of what an n-th degree polynomial looks like, and to be able to find the asymptotes of a rational function. Students who master these ideas will be better prepared for the chapter on curve sketching.

Exercise 59 is the first of several in this chapter asking students to find what type of function best fits a set of data. (See also Section 2.4, Exercises 57, 58 and 59, and Review Exercise 111.) The class can easily get bogged down in these exercises, particularly if you decide to explore the regression features in a calculator such as the TI-84 Plus C. But there is a powerful payoff in terms of mastery of functions for the student who succeeds at these exercises.

Section 2.4

Some instructors may prefer at this point to continue with Chapter 3 and to postpone discussion of the exponential and logarithmic functions until later. The overwhelming preference of instructors we surveyed, however, was to cover exponential and logarithmic functions early and then to use these functions throughout the rest of the course. Instructors who wish to postpone this material will also need to omit for now those examples and exercises in Sections 3.1–4.3 that refer to exponential and logarithmic functions.

Students typically have no problem with $f(x)=2^x$, but the number e often remains a mystery. Like π, the number e is a transcendental number, but students have had years of schooling to get used to π. Have your students approximate e with a calculator, as the textbook does before the definition of e. Notice how we use compound interest to help students get a handle on this number.

Section 2.5

Logarithms are a very difficult topic for many students. It's easy to say that a logarithm is just an exponent, but the fact that it is the exponent to which one must raise the base to get the number whose logarithm we are calculating is a rather obtuse concept. Therefore, spend lots of time going over examples that can be done without a calculator, such as $\log_2 8$. Students will also tend to come up with many incorrect pseudoproperties of logarithms, similar in form to the properties of logarithms given in this section. Take as much time and patience as necessary in gently correcting the many errors students inevitably will make at first.

Even after receiving a thorough treatment of logarithms, some students will still be stumped when solving a problem such as Example 8. Some of these students can get the correct answer using trial-and-error. The instructor should take consolation in the fact that at least such a student understands exponentials better than the one who uses logarithms incorrectly to solve Example 8 and comes up with the nonsensical answer $t = -7.51$ without questioning whether this makes sense. Be sure to teach your students to question the reasonableness of their answers; this will help them catch their errors.

Section 2.6

This section gives students much needed practice with exponentials and logarithms, and the applications keep students interested and motivated. Instructors should keep this in mind and not worry about having students memorize formulas. We have removed the formulas for present value in this edition, having decided that it's better for students to just solve the compound amount formula for P. This reduces by two the number of formulas that students need to remember.

There is a summary of graphs of basic functions in the end-of-chapter review.

Section 3.1

This is the first section on calculus, and perhaps the most important, since limits are what really distinguish calculus from algebra. Students will have the best understanding of limits if they have studied them graphically (as in Exercises 11–18), numerically (as in Exercises 21–26), and analytically (as in Exercises 35–62). The graphing calculator is a powerful tool for studying limits. Notice in Example 12 (c) and (d) that we have modified the method of finding limits at infinity by dividing by the highest power of x in the denominator, which avoid the problem of division by 0.

Section 3.2

The section on continuity should be straightforward if students have mastered limits from the previous section.

Section 3.3

This section introduces the derivative, even though that term doesn't appear until the next section. In a class full of business and social science majors, an instructor may wish to place less emphasis on velocity, an approach more suited to physics majors. But we have found velocity to be the manifestation of the derivative that is most intuitive to all students, regardless of their major.

Instructors in a hurry can skip the material on estimating the instantaneous rate of change from a set of data, but it helps solidify students' understanding of the derivative by giving them one more point of view.

Section 3.4

Students who have learned differentiation formulas in high school usually want (and deserve) some explanation of why they need to learn to take derivatives using the definition. You might try explaining to your students that getting the right formula is not the only goal; graphing calculators can give derivatives numerically. The most important thing for students to learn is the concept of the derivative, which they don't learn if they only memorize differentiation formulas.

Zooming in on a function with a graphing calculator until the graph appears to be a straight line gives students a very concrete image of what the derivative means.

After students have learned the differentiation formulas, they may forget about the definition of derivative. We have found that if we want them to use the definition on a test, it is important to say so clearly and emphatically, or they will simply use the shortcut formulas.

Section 3.5

One way to get students to focus on the concept of the derivative, rather than the mechanics, is to emphasize graphical differentiation. We have therefore devoted an entire section to this topic. Graphical differentiation is difficult for many students because there are no formulas to rely on. One must thoroughly understand what's going on to do anything. On the other hand, we have seen students who are weak in algebra but who possess a good intuitive grasp of geometry find this topic quite simple.

Section 4.1

Students tend to learn these differentiation formulas fairly quickly. These and the formulas in the next few sections are included in a summary at the end of the chapter.

Section 4.2

The product and quotient rules are more difficult for students to keep straight than those of the previous section. People seem to remember these rules better if they use an incantation such as "The first times the derivative of the second, plus the second times the derivative of the first." Some instructors have argued that this formulation of the product rule doesn't generalize well to products of three or more functions, but that's not important at this level. Some instructors allow their students to bring cards with formulas to the tests. This does not eliminate the need for students to understand the use of the formulas, but it does eliminate the anxiety students may have about forgetting a key formula under the pressure of an exam.

Section 4.3

No matter how many times an instructor cries out to his or her students, "Remember the chain rule!", many will still forget this rule at some time later in the course. But if a few more students remember the rule because the instructor reminds them so often, such reminders are worthwhile.

Section 4.4 and 4.5

In going through these sections, you may need to frequently refer to the rules of differentiation in the previous sections. You may also need to review the last three sections of Chapter 2.

Section 5.1 and 5.2

If students have understood Chapter 3, then the connection between the derivative, increasing and decreasing functions, and relative extrema should be obvious, and these sections should go quickly and smoothly.

Section 5.3

Students often confuse concave downward and upward with increasing and decreasing; carefully go over Figure 31 or the equivalent with your class.

Section 5.4

Graphing calculators have made curve sketching techniques less essential, but curve sketching is still one of the best ways to unify the various concepts introduced in this and the previous two chapters. Students should use graphing calculators to check their work.

Because this section is the culmination of many ideas, students often find it difficult and start to forget things they previously knew. For example, a student might state that a function is increasing on an interval and then draw it decreasing. The best solution seems to be lots of practice with immediate help and feedback from the instructor.

Students sometimes stumble over this topic because they use the rules for differentiation incorrectly, or because they make mistakes in algebra when simplifying. Exercises such as 29–34 are excellent for testing whether students really grasp the concepts.

Section 6.1

This section should not be conceptually difficult, but students need constant reminders to check the endpoints of an interval when finding the absolute maxima and minima.

Section 6.2

This section is one of the high points of the course. Some of the best applications of calculus involve maxima and minima. Notice that some exercises have a maximum or minimum at the endpoint of an interval, so students cannot ignore checking endpoints.

Almost everyone finds this material difficult because most people are not skilled at word problems. Remind your students that if they ever wonder whether mathematics is of any use, this section will show them.

Why are word problems so difficult? One theory is that word problems require the use of two different modes of thinking, which students are using simultaneously for the first time. People use words in daily life without difficulty, but when they study mathematics, they often turn off that part of their brain and begin thinking in a very formal, mechanical way. In word problems, both modes of thinking must be active. If and when the NCTM Standards become widely accepted in the schools, children will get more practice at an early age in such ways of thinking. Meanwhile, the steps for solving applied problems given in this book might make the process a little more straightforward, and hence achievable by the average student.

Section 6.3

This section continues the ideas of the previous one. The point of studying economic lot size should not be to apply Equation (3), but to learn how to apply calculus to solve such problems. We therefore urge you to cover Exercises 17–20, in which we vary the assumptions, so Equation (3) does not necessarily apply. In this edition, we have changed the presentation to be consistent with that of business texts.

The material on elasticity can be skipped, but it is an important application that should interest students who have studied even a little economics.

Section 6.4

There are two main reasons for covering implicit differentiation. First, it reinforces the chain rule. Second, it is needed for doing related rate problems. If you skip related rates due to lack of time, it is not essential to cover implicit differentiation, either.

Section 6.5

Related rate applications are less important than applied extrema problems, but they use some of the same skills in setting up word problems, and for that reason are worth covering. The best application exercises are under the heading "Physical Sciences," because those are the exercises in which no formula is given to the student; the student must construct a formula from the words. The geometrical formulas needed are kept to a minimum: the Pythagorean theorem, the area of a circle, the volume of a sphere, the volume of a cone, and the volume of a cylinder with a triangular cross section. Some instructors allow their students to use a card with such formulas on the exam. These formulas are summarized in a table in the back of the book.

Section 6.6

Differentials may be skipped by instructors in a hurry; you need not fear that this omission will hamper your students in the chapter on integration. The differentials used there are not the same as those used here, and the required techniques are easily picked up when integration by substitution is covered. The exception is for instructors who intend to cover Section 10.3 on Euler's Method, since differentials are used to motivate and derive that method.

As in the previous edition, our presentation of differentials emphasizes linear approximation, a topic of considerable importance in mathematics.

Section 7.1

Students sometimes start to get differentiation and antidifferentiation confused when they reach this section. Some believe the antiderivative of x^{-2} is $(-1/3)x^{-3}$; after all, if n is −2, isn't $n + 1 = -3$? Carefully clarify this point.

Section 7.2

The main difficulty here is teaching students what to choose as u. The advice given before Example 3 should be helpful.

Section 7.3

Some instructors who are pressed for time go lightly over the topic of the area as the limit of the sum of rectangular areas. This is possible, but care should be taken that students don't lose track of what the definite integral represents. Also, a light treatment here lessens the excitement of the Fundamental Theorem of Calculus.

We have continued the trend of the previous edition in covering three ways of approximating a definite integral with rectangles: the right endpoint, the left endpoint, and the midpoint. The trapezoidal rule is briefly introduced here as the average of the left sum and the right sum.

Section 7.4

The Fundamental Theorem of Calculus should be one of the high points of the course. Make a big deal about how the theorem unifies these two separate topics of area as a limit of sums and the antiderivative.

When using substitution on a definite integral, the text recommends changing the limits and the variable of integration. (See Example 4 and the Caution which follows the example.) Some instructors prefer instead to have their students solve an indefinite integral, and then to evaluate the integral using the limits on x. One advantage of this method is that students don't have to remember to change the limits. This method also has two disadvantages. The first is that it takes slightly longer, since it requires changing the integral to u and then back to x. Second, it prevents students at this stage from solving problems such as $\int_0^{1/2} x\sqrt{1-16x^4}\,dx$, which can be solved using the substitution $u = 4x^2$ and the fact that the integral $\int_0^1 \sqrt{1-u^2}\,du$ represents the area of a quarter circle. This is one section in which we deliberately did not use more than one method of presentation, because this would inevitably lead to confusion in the minds of some students.

Section 7.5

This section gives more motivation to the topic of integration. Consumers' and producers' surplus are important, realistic applications. We have downplayed sketching the curves that bound the area under consideration. Such sketches take time and are not necessary in solving these problems. But they clarify what is happening and make it possible to avoid memorizing formulas. Using a graphing calculator to sketch the curves can be helpful.

Section 7.6

The ubiquity of computers and graphing calculators has made numerical integration more important. Rather than computing a definite integral by an integration technique, one can just as easily enter the function into a calculator and press the integration key. Point out to students that this is valuable when the function to be integrated is complicated. On the other hand, using the antiderivative makes it easier to see the effect of changing the upper limit, say, from 2 to 3, or for working with the definite integral when one or both limits are parameters, such as a and b, rather than numbers.

Simpson's rule is the most accurate of the simple integration formulas. To achieve greater accuracy, a more complicated method must be used. This is why, unlike the trapezoidal rule, Simpson's rule is actually used by mathematicians and engineers.

You may wish to give your students the programs for the trapezoidal rule and Simpson's rule in *The Graphing Calculator Manual* that is available with the text.

Section 8.1

Students usually find column integration simpler than traditional integration by parts. We show both methods to give instructors a choice, and also to emphasize that the two methods are equivalent. Column integration makes organizing the details simpler, but is no more mechanical than the traditional method, as some have mistakenly claimed. At Hofstra University, students even use this method when neither the instructor nor the book discuss it. They find out about it from other students, and so it has become an underground method. Some instructors feel that students will lose any theoretical understanding of what they are doing if they use this method. Our experience is that almost no students at this level have a theoretical understanding of what integration by parts is about, but the better students can at least master the mechanics. With column integration, almost all of the students master the mechanics.

Section 8.2 and 8.3

These two sections give more applications of integration. Coverage of either section is optional.

Section 8.4

Improper integration is not really an application of integration, but it makes further applications of integration possible.

Many mathematicians use shorthand notation such as the following: $\int_0^\infty e^{-x}dx = -e^{-x}\Big|_0^\infty = 0 - (-1) = 1.$ For students at this level, it may be best to avoid the shorthand notation.

Section 9.1

The major difficulty students have with this section, and indeed with this entire chapter, is that they cannot visualize surfaces in 3-dimensional space, even though they live there. Fortunately, such visualization is not really necessary for doing the exercises in this chapter. A student who wants to explore what various surfaces look like can use any of the commercial or public domain computer programs available.

Section 9.2

Students who have mastered the differentiation techniques should have no difficulty with this section.

Section 9.3

This section corresponds to the section on applied extrema problems in the chapter on applications of the derivative, but with less emphasis on word problems. In Exercise 36, we revisit the topic of the least squares line, first covered in Section 1.3.

Section 9.4

Lagrange multipliers are an important application of calculus to economics. At some colleges, the business school is very insistent that the mathematics department cover this material.

Section 9.5

This section corresponds to the section on differentials in the chapter on applications of the derivative.

Section 9.6

Students who have trouble visualizing surfaces in 3-dimensional space are sometimes bothered by double integrals over variable regions. Instructors should assure such students that all they need to do is draw a good sketch of the region in the xy-plane, and not try to draw the volume in three dimensions.

Section 10.1

Differential equations of the form $dy/dx = f(x)$ are treated lightly in this section because they were already covered in the chapter on integration, although the terminology and notation were different then. Remind students that solving such differential equations is the same as antidifferentiation. The rest of the section is on separable differential equations. Students sometimes have trouble with this section because they have forgotten how to find an antiderivative, particularly one requiring substitution.

Section 10.2

If you get this far, your students have covered most of the techniques for solving first-order differential equations. You can find further techniques in differential equations texts, but most first-order equations that come up in real applications are separable, linear, or not solvable by any exact method.

Section 10.3

This is one of the most calculator/computer-intensive sections of the book. In practice, more accurate methods than Euler's method are almost always used, but Euler's method introduces students to a way of solving problems that would otherwise be beyond their grasp. You may wish to give your students the program for Euler's method in *The Graphing Calculator Manual* that is available with the text.

Section 10.4

This is a fun section of assorted applications, showing students that the techniques they have learned were not in vain. You can pick and choose those applications of greatest interest to yourself and your students. You can also supplement the text with applications from other sources, such as those published by the Consortium for Mathematics and Its Applications Project (COMAP).

Chapter 11

Probability is one of the best applications of calculus around. In fact, statistics instructors sometimes feel the temptation to start discussing the definite integral even when their students know no calculus. This chapter is just a brief introduction, but it covers some of the most important concepts, such as mean, variance, standard deviation, expected value, and probability as the area under the curve. The third section covers three of the most important continuous probability distributions: uniform, exponential, and normal.

Chapter 12

Except for geometric series, most of the material in this chapter is of greater interest to the professional mathematician or engineer than to the student in business, management, economics, life sciences or social sciences, so many instructors may choose to skip this chapter.

Many students confuse sequences with series, and often have trouble with the various tests for convergence. To avoid these sources of confusion, we emphasize summation as a unifying concept, whether of a few terms of a sequence or of an infinite series. Except for convergence of geometric series and a few words on the interval of convergence, we devote little coverage to the topic of convergence. We believe this approach is appropriate for a course at this level.

Section 12.1

Geometric sequences are the most important type of sequences for applications. Even instructors who wish to skip most of this chapter may want to cover the first two sections.

Section 12.2

This material is similar to the material in the Mathematics of Finance chapter in our textbook *Finite Mathematics*. The section shows how geometric sequences are critical for an understanding of annuities, mortgages, and amortization. Don't be put off by the strange notation for the amount or the present value of an annuity; this notation is not at all strange in the world of finance.

Section 12.3

Taylor polynomials are introduced here as an approximation method, with no hint of infinite series.

Section 12.4

The emphasis here is on geometric series, the most important and simplest type of infinite series to understand.

Section 12.5

Some students find Taylor series a strange and abstract concept. To help make this concept more concrete, cover Example 4 on the normal curve, as well as the derivation of the rule of 70 and the rule of 72, introduced without proof in Chapter 2.

Section 12.6

Students with a "zero" feature on their calculator may lack motivation to learn Newton's method unless you can interest them in how one might develop techniques for finding a zero. Newton's method is not, however, the method typically used by calculators; calculator manufacturers are usually reluctant to discuss the actual algorithms.

Section 12.7

We have no applications for this sections, but students and instructors who enjoy symbol manipulation may still find this section satisfying.

Chapter 13

This chapter is a brief introduction to trigonometry and its uses in calculus. Students who need a more thorough treatment of this subject would be better served by a calculus book designed for mathematics majors. The presentation is brief, with a limited number of examples. As a result, students may find some of these exercises challenging. Therefore, tread carefully through this chapter.

PRETESTS
AND
ANSWERS

CALCULUS WITH APPLICATIONS Name:

Pretest, Form A

1. Evaluate the expression $-x^2 + 3y - z^3$ when $x = -2$, $y = 3$, and $z = -1$. 1. ________

Perform the indicated operations.

2. $(2x^2 - 3x + 7) - (5x^2 - 8x - 9)$ 2. ________

3. $(y - 4)^2$ 3. ________

4. $(2x - 1)(x^2 + 3x - 4)$ 4. ________

5. $(5a + 2b)(5a - 2b)$ 5. ________

Factor each polynomial completely.

6. $3x^2y^3 - 6x^3y^2 + 15x^2y^2$ 6. ________

7. $2ac - 3ad + 8bc - 12bd$ 7. ________

Solve each equation.

8. $6(x - 1) - 4(2x + 8) = 2 - 5(x + 2)$ 8. ________

9. $\frac{1}{4}x - 7 = \frac{2x}{3} + \frac{1}{2}$ 9. ________

10. $\frac{x - 1}{5} = \frac{3 - 2x}{4}$ 10. ________

11. $(x - 2)(x + 1) = 4$ 11. ________

12. Solve the inequality $6x - 8(x + 2) \leq 5 - (x + 14)$. Write your answer in interval notation. 12. ________

13. Solve the equation $2x + 4y = ay - bx$ for y. 13. ________

14. Solve the equation $\frac{5}{a} + \frac{c}{2b} = \frac{7}{3a}$ for a. 14. ________

15. Solve the following system of equations.

$$\begin{aligned} 3x - 2y &= 12 \\ -4x + 5y &= -23 \end{aligned}$$

15. ______________

Perform the indicated operation. Write answers in lowest terms.

16. $\dfrac{18a^2b^2}{27xy^3} \cdot \dfrac{10xy^2}{8ab^2}$

16. ______________

17. $\dfrac{2x + 8}{3y - 15} \div \dfrac{x^2 + 7x + 12}{y^2 - 10y + 25}$

17. ______________

18. $\dfrac{4}{x^2 - 1} + \dfrac{2}{x^2 + 3x + 2}$

18. ______________

Simplify each expression. Write answers with only positive exponents.

19. $(2x^2y^{-3})^{-3}$

19. ______________

20. $\dfrac{6x^{-2}y^5}{15x^4y^{-2}}$

20. ______________

Simplify each radical. Assume all variables represent nonnegative real numbers.

21. $\sqrt{72x^3y^4}$

21. ______________

22. $\sqrt[3]{72x^3y^4}$

22. ______________

Write an equation in the form $ax + by = c$ ***for each line.***

23. The line through the points with coordinates $(-3, -14)$ and $(5, 2)$

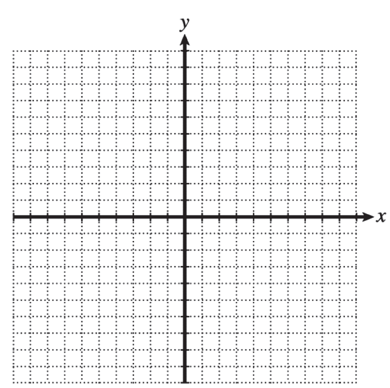
23. ______________

24. The line through the points with coordinates $(3, -7)$ and $(3, 5)$

24. ______________

25. Graph the solution of the inequality $2x - 3y \leq 12$.

25.



CALCULUS WITH APPLICATIONS Name:

Pretest, Form B

Choose the best answer.

1. Evaluate the expression $\frac{y^2 - z}{-x^2 + 6}$ when $x = -2$, $y = 4$, and $z = -8$. 1. ________

(a) $\frac{12}{5}$ (b) 4 (c) 12 (d) $\frac{4}{5}$

Perform the indicated operations.

2. $(x^2 - 3x + 7) + (4x^3 - 6x^2 - 5x + 4)$ 2. ________

(a) $4x^3 - 6x^4 - 8x^2 + 11$ (b) $4x^3 - 5x^2 - 8x + 11$

(c) $4x^3 - 5x^2 - 2x + 11$ (d) $4x^3 - 7x^2 - 8x + 11$

3. $(5x - 4w)^2$ 3. ________

(a) $25x^2 - 16w^2$ (b) $25x^2 + 16w^2$

(c) $25x^2 - 40wx + 16w^2$ (d) $25x^2 - 20wx + 16w^2$

4. $(x - 3)(x^2 + x - 2)$ 4. ________

(a) $x^3 - 2x^2 - 5x + 6$ (b) $x^3 - 3x^2 - 5x + 6$

(c) $x^3 - 3x^2 + 6x + 6$ (d) $x^3 - 2x^2 + 5x + 6$

5. $(4x + 9)(4x - 9)$ 5. ________

(a) $16x^2 + 72x - 81y^2$ (b) $16x^2 - 72xy - 81y^2$

(c) $16x^2 - 81y^2$ (d) $16x^2 - 72xy + 81y^2$

Factor each polynomial completely.

6. $14a^2b^3 - 7a^2b^2 + 35ab^4$ 6. ________

(a) $7ab(2ab^2 - ab + 5b^3)$ (b) $a^2b^3(14 - 7b + 35b^2)$

(c) $7a^3b(2b^2 - 7b + 5b^3)$ (d) $7ab^2(2ab - a + 5b^2)$

7. $6xt + 8x - 3yt - 4y$ 7. ________

(a) $(2x - y)(3t + 4)$ (b) $(2x + y)(3t - 4)$

(c) $(2x - y)(3t - 4)$ (d) $(2x + y)(3t + 4)$

Solve each equation.

8. $4m - (7m - 6) = -m$ 8. ______________

(a) $\frac{3}{2}$ (b) $-\frac{3}{2}$ (c) -3 (d) 3

9. $-\frac{5}{3} + \frac{2}{r-1} = \frac{1}{6}$ 9. ______________

(a) $-\frac{1}{3}$ (b) $\frac{23}{11}$ (c) 3 (d) -6

10. $\frac{3y+2}{5} = \frac{7-y}{4}$ 10. ______________

(a) $\frac{43}{7}$ (b) $\frac{27}{7}$ (c) $\frac{27}{17}$ (d) $\frac{43}{17}$

11. $2z^2 + z = 28$ 11. ______________

(a) $-4, 3$ (b) $4, -3$

(c) $-4, \frac{7}{2}$ (d) $4, -\frac{7}{2}$

12. Solve the inequality $-6y + 2 \geq 4y - 7$.
Write your answer in interval notation. 12. ______________

(a) $\left(-\infty, -\frac{9}{10}\right]$ (b) $\left[\frac{1}{2}, \infty\right)$

(c) $\left[\frac{9}{10}, \infty\right)$ (d) $\left(-\infty, \frac{9}{10}\right]$

13. Solve the equation $x = \frac{4(y-z)}{3k}$ for y. 13. ______________

(a) $y = \frac{4}{3kx + 4z}$ (b) $y = \frac{4}{kx - z}$

(c) $y = -\frac{3kxz}{4}$ (d) $y = \frac{3x + 4z}{4}$

14. Solve the equation $\frac{4}{x} + \frac{a}{y} = \frac{2}{3}$ for x. 14. ______________

(a) $x = \frac{2xy - 12y}{3s}$ (b) $x = \frac{12y}{2y - 3a}$

(c) $x = \frac{12y + 3ax}{2y}$ (d) $x = \frac{3a - 2y}{12y}$

15. Solve the following system of equations and then determine the value of $x + y$ for the solution. 15. ______

$$3x + 2y = 0$$
$$x - 5y = 17$$

(a) -1 (b) 1 (c) 2 (d) -3

Perform the indicated operation. Write answer in lowest terms.

16. $\dfrac{6yz^3}{30a^2b^4} \cdot \dfrac{15a^3b^3}{12y^2z^3}$ 16. ______

(a) $\dfrac{3a^2}{12aby}$ (b) $\dfrac{4y^3z^6}{25a^5b^7}$

(c) $\dfrac{a}{4by}$ (d) $\dfrac{b}{4ay}$

17. $\dfrac{x^2 - y^2}{4a^5b^7} \div \dfrac{x^2 + 3xy + 2y^2}{12a^3b^{12}}$ 17. ______

(a) $\dfrac{3b^5}{2a^2}$ (b) $\dfrac{3b^5(x+y)}{a^2(x-2y)}$

(c) $\dfrac{3b^5(x-y)}{a^2(x+2y)}$ (d) $\dfrac{3b^3(x+y)}{(x-2y)}$

18. $\dfrac{1}{2x} - \dfrac{2}{3y} + \dfrac{5}{6xy}$ 18. ______

(a) $\dfrac{2}{3xy}$ (b) $\dfrac{3y-4x+5}{6xy}$

(c) $3y - 4x + 5$ (d) $\dfrac{4x-3y+5}{6xy}$

Simplify each expression. Write answers with only positive exponents.

19. $(3a^{-2}b^3)^{-4}$ 19. ______

(a) $-\dfrac{12}{a^6b}$ (b) $-\dfrac{12a^8}{b^{12}}$

(c) $\dfrac{a^8}{12b^{12}}$ (d) $\dfrac{a^8}{81b^{12}}$

20. $\left(\dfrac{r^2m^{-1}}{r^3m^2}\right)^{-2}$ 20. ______

(a) r^2m^2 (b) $\dfrac{1}{r^2m^2}$ (c) r^2m^6 (d) $\dfrac{1}{r^2m^6}$

Simplify each radical. Assume all variables represent nonnegative real numbers.

21. $\sqrt{108a^4b^3}$ 21. ____________

(a) $3a^2b\sqrt{12b}$ (b) $6a^2b\sqrt{3b}$

(c) $6a^2b\sqrt{3a}$ (d) $54a^2b\sqrt{b}$

22. $\sqrt[3]{108a^4b^3}$ 22. ____________

(a) $3ab\sqrt[3]{4a}$ (b) $6a^2b\sqrt[3]{3b}$

(c) $36ab\sqrt[3]{a}$ (d) $9a^2b\sqrt[3]{12a}$

Write an equation in the form $ax + by = c$ ***for each line.***

23. The line through the points with coordinates $(1, -1)$ and $(-1, -2)$ 23. ____________

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

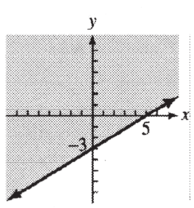
(c) $x + 2y = -3$ (d) $x - 2y = -3$

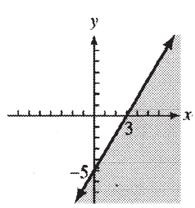
24. The line through the points with coordinates $(-5, -2)$ and $(-3, -2)$ 24. ____________

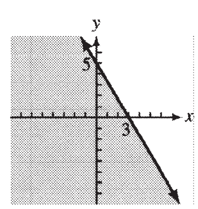
(a) $x + y = -2$ (b) $x = -2$

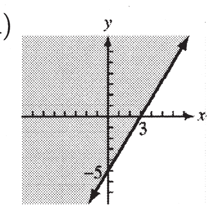
(c) $x - y = -2$ (d) $y = -2$

25. Graph the solution of the inequality $5x - 3y \geq 15$. 25. ____________

(a)


(b)


(c)


(d)


ANSWERS TO PRETESTS

PRETEST, FORM A

1. 6

2. $-3x^2 + 5x + 16$

3. $y^2 - 8y + 16$

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

5. $25a^2 - 4b^2$

6. $3x^2y^2(y - 2x + 5)$

11. $-2, 3$

12. $[-7, \infty)$

13. $y = \frac{(b+2)x}{a-4}$

14. $a = -\frac{16b}{3c}$

15. $(2, -3)$

16. $\frac{5a}{6y}$

20. $\frac{2y^7}{5x^6}$

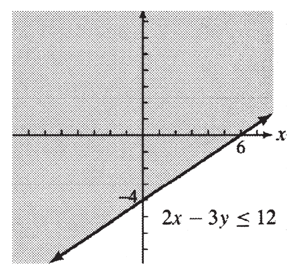
21. $6xy^2\sqrt{2x}$

22. $2xy\sqrt[3]{9y}$

23. $2x - y = 8$

24. $x = 3$

25.



PRETEST, FORM B

1. (c)

2. (b)

3. (c)

4. (a)

5. (c)

6. (d)

7. (a)

8. (d)

9. (b)

10. (c)

11. (c)

12. (d)

13. (d)

14. (b)

15. (a)

16. (c)

17. (c)

18. (b)

19. (d)

20. (c)

21. (b)

22. (a)

23. (a)

24. (d)

25. (b)

FINAL EXAMINATIONS AND ANSWERS

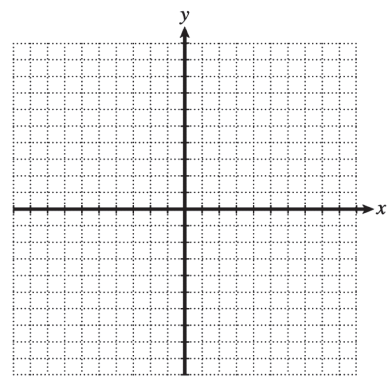
CALCULUS WITH APPLICATIONS Name:

Final Examination, Form A

1. Find the coordinates of the vertex of the graph of $f(x) = -2x^2 + 30x + 45$. 1. ______

2. Write the equation $2^a = d$ using logarithms. 2. ______

3. Graph the function $y = \log_2(x - 3) + 4$. 3.



4. Evaluate $\lim_{x \to 4} \frac{x-4}{\sqrt{x} - 2}$. 4. ______

5. Find all values of x at which $g(x) = \frac{x-2}{x-5}$ is not continuous. 5. ______

6. Find the average rate of change of $y = \sqrt{2x + 1}$ between $x = 4$ and $x = 12$. 6. ______

7. Find the derivative of $y = 7x^2 e^{3x}$. 7. ______

8. Find the derivative of $y = \frac{\ln(3x)}{x+1}$. 8. ______

9. Find the instantaneous rate of change of $s(t) = 3t^2 - \frac{8}{t}$ at $t = 2$. 9. ______

10. Find an equation of the tangent line to the graph of $y = (x^2 + 3x + 3)^8$ at the point $(-1, 1)$. 10. ______

11. Find $h'(2)$ if $h(x) = \frac{6}{\sqrt{4x+17}}$. 11. ______

12. Find the largest open intervals where f is increasing or decreasing if $f(x) = 2x^3 - 24x^2 + 72x$. 12. ______

13. Find the locations and values of all relative extrema of g if $g(x) = \dfrac{x^2 + 5x + 3}{x - 1}$. 13. ______

14. For the function $f(x) = x^4 - 4x^3 - 5$, find

(a) all intervals where f is concave upward; 14. (a) ______

(b) all intervals where f is concave downward; (b) ______

(c) all points of inflection. (c) ______

15. Find the fourth derivative of $h(x) = xe^x$. 15. ______

16. Find the locations and values of all absolute extrema of $f(x) = x^3 - 6x^2$ on the interval $[-1, 2]$. 16. ______

17. For a particular commodity, its price per unit in dollars is given by $P(x) = 120 - \dfrac{x^2}{10}$, where x, measured in thousands, is the number of units sold. This function is valid on the interval $[0, 34]$. How many units must be sold to maximize revenue? 17. ______

18. Find $\frac{dy}{dx}$ if $3\sqrt{x} - 5y^3 = 7xy$. 18. ______

19. If $xy = x - 9$, find $\frac{dy}{dt}$ if $\frac{dx}{dt} = 12$, $x = -3$, and $y = 4$. 19. ______

20. If $y = -3(2 + x^2)^3$, find dy. 20. ______

21. Using differentials, approximate the volume of coating on a sphere of radius 5 inches, if the coating is 0.03 inch thick. 21. ______

22. Find $\int (3x^2 - 7x + 2)\,dx$. 22. ______

23. Find $\int \frac{8}{x+9}\,dx$. 23. ______

24. Evaluate $\int_0^2 x\sqrt{3x^2 + 4}\,dx$. 24. ______

25. Find the area of the region between the x-axis and the graph of $f(x) = xe^{x^2}$ on the interval $[0, 2]$. 25. ______

26. Find the area of the region enclosed by the graphs of $f(x) = x^2 - 4$ and $g(x) = 1 - x^2$. 26. ______

27. Find $\int x^2 e^x dx$. 27. ______

28. Evaluate $\int_1^{e^2} 3x \ln x\, dx$. 28. ______

29. Find the average value of $f(x) = x(x^2 + 1)^3$ over the interval $[0, 2]$. 29. ______

30. Find the volume of the solid of revolution formed by rotating the region bounded by the graphs of $f(x) = \sqrt{x + 4}$, $y = 0$, and $x = 12$ about the x-axis. 30. ______

31. Determine whether the improper integral $\int_{-\infty}^{-1} x^{-2}\, dx$ converges or diverges. If it converges, find its value. 31. ______

32. If $f(x, y) = 3x^2 - 4xy + y^3$, find $f_{xy}(1, -3)$. 32. ______

33. For $f(x, y) = 2x^2 - 2xy + 2y^2 + 4x + 4y + 5$, find all of the following:

(a) relative maxima; 33. (a) ______

(b) relative minima; (b) ______

(c) saddle points. (c) ______

34. Maximize $f(x, y) = x^2 y$, subject to the constraint $y + 4x = 84$. 34. ______

35. Find dz, given $z = 3x^2 - 4xy + y^2$, where $x = 0$, $y = 2$, $dx = 0.02$, and $dy = 0.01$. 35. ______

36. Evaluate $\int_1^2 \int_0^3 e^{2x}\, dy\, dx$. 36. ______

37. Find the general solution of the differential equation $\frac{dy}{dx} = \frac{1 + e^x}{2y}$. 37. ______

38. Find the particular solution of the differential equation $\frac{dy}{dx} = 3x^2 - 7x + 2$; $y = 4$ when $x = 0$. 38. ______

39. The marginal cost function for a particular commodity is $\frac{dy}{dx} = 8x - 9x^2$. The fixed cost is \$20. Find the cost function.

39. ______________________

40. The probability density function of a random variable is defined by $f(x) = \frac{1}{4}$ for x in the interval $[12, 16]$. Find $P(X \leq 14)$.

40. ______________________

41. For the probability density function $f(x) = 3x^{-4}$ on $[1, \infty)$, find

(a) the expected value;

(b) the variance;

(c) the standard deviation.

41. (a) ______________________

(b) ______________________

(c) ______________________

42. The average height of a particular type of tree is 20 feet, with a standard deviation of 2 feet. Assuming a normal distribution, what is the probability that a tree of this kind will be shorter than 17 feet?

42. ______________________

43. For the function $f(x) = e^{-3x}$, find

(a) the Taylor polynomial of degree 4 at $x = 0$;

(b) an approximation, rounded to four decimal places, of $e^{-0.03}$ using the Taylor polynomial from part (a).

43. (a) ______________________

(b) ______________________

44. Find the sum of the convergent geometric series $5 + \frac{5}{3} + \frac{5}{9} + \frac{5}{27} + \cdots$.

44. ______________________

45. Use Newton's method to find a solution to the nearest hundredth of $3x^3 - 2x^2 + x - 1 = 0$ in the interval $[0, 1]$.

45. ______________________

46. Use l'Hospital's rule to find $\lim\limits_{x \to \infty} \frac{3e^{2x} - 3}{x}$.

46. ______________________

47. Find the derivative of $f(x) = \tan(x^2 + 1)$.

47. ______________________

48. Find the derivative of $y = x^3 \sin^2 x$.

48. ______________________

49. Find $\int \sec^2(3x + 1)\,dx$.

49. ______________________

50. Evaluate $\int_0^{\pi/6} \sin^3 x \cos x\,dx$.

50. ______________________

CALCULUS WITH APPLICATIONS Name:

Final Examination, Form B

Choose the best answer.

1. Find the coordinates of the vertex of the graph of $f(x) = 2x^2 + 10x - 17$. 1. ______

(a) $\left(-\frac{5}{2}, -\frac{59}{2}\right)$ (b) $\left(\frac{5}{2}, -\frac{59}{2}\right)$ (c) $(-5, -42)$ (d) $(5, -42)$

2. Write the equation $m^P = q$ using logarithms. 2. ______

(a) $\log_m p = q$ (b) $\log_q p = m$

(c) $\log_p q = m$ (d) $\log_m q = p$

3. Solve $\left(\frac{1}{e}\right)^{2x} = 14$. (Round to nearest thousandth.) 3. ______

(a) -1.320 (b) 2.639 (c) -2.639 (d) 1.320

4. Evaluate $\lim_{x \to 9} \frac{x-9}{\sqrt{x}-3}$. 4. ______

(a) 0 (b) 3 (c) 6 (d) The limit does not exist.

5. Find all values of x at which $f(x) = \dfrac{x^2 - 5x + 6}{x^2 - 7x + 12}$ is not continuous. 5. ______

(a) 3 (b) 4 (c) 3 and 4

(d) The function is continuous everywhere.

6. Find the average rate of change of $y = x^2 + x$ between $x = 4$ 6. ______

(a) 9 (b) 10 (c) 17 (d) 25

7. Find the derivative of $y = -3x^3e^{2x}$. 7. ______

(a) $-27x^2e^{2x} - 6x^3e^{2x}$ (b) $-18x^2e^{3x}$

(c) $-9x^2e^{2x} - 6x^3e^{2x}$ (d) $-6x^2e^{2x} - 6x^3e^{2x}$

8. Find the derivative of $y = \frac{x^2}{\ln 3x}$. 8. ______

(a) $\dfrac{2x^2}{(\ln 3x)^2}$ (b) $\dfrac{6x \ln 3x - x}{3(\ln 3x)^2}$

(c) $\dfrac{2x \ln 3x - x}{(\ln 3x)^2}$ (d) $\dfrac{6x \ln 3x + x}{3(\ln 3x)^2}$

9. Find the instantaneous rate of change of $s(t) = \frac{t^2}{2} - \frac{2}{t^2}$ at $t = 2$. 9. ________

(a) $\frac{3}{2}$ (b) $\frac{5}{2}$ (c) $\frac{7}{2}$ (d) $\frac{9}{2}$

10. Find an equation of the tangent line to the curve $f(x) = -\frac{1}{x+2}$ at the point $\left(2, -\frac{1}{4}\right)$. 10. ________

(a) $x - 16y = 6$ (b) $x - 4y = 3$

(c) $f'(x) = \frac{1}{16}$ (d) $y = \frac{1}{(x+2)^2}$

11. Find $h'(3)$ if $h(x) = -\frac{400}{\sqrt{3x+7}}$. 11. ________

(a) 100 (b) $\frac{25}{8}$ (c) $\frac{75}{8}$ (d) 200

12. Find the largest open interval(s) over which the function $g(x) = x^3 - 12x^2 + 36x + 1$ is increasing. 12. ________

(a) $(2, 6)$ (b) $(-\infty, 2)$

(c) $(-\infty, 6)$ (c) $(-\infty, 2)$ and $(6, \infty)$

13. Find the location and value of all relative extrema for the function $f(x) = \frac{x^2 + 5x + 3}{x - 1}$. 13. ________

(a) Relative minimum of 1 at -2; relative maximum of 13 at 4

(b) Relative maximum of 1 at -2; relative minimum of 13 at 4

(c) Relative minimum of 1 at 4; relative minimum of 13 at -2

(d) No relative extrema

14. Find the coordinates of all points of inflection of the function $g(x) = x^3 - 6x^2$. 14. ________

(a) $(2, -16)$ (b) $(2, -12)$ (c) $(2, 0)$ (d) $(-2, 16)$

15. Find the third derivative of $f(x) = \sqrt{2x + 1}$. 15. ________

(a) $\frac{3}{8}(2x+1)^{-5/2}$ (b) $3(2x+1)^{-5/2}$

(c) $-(2x+1)^{-3/2}$ (d) $-\frac{1}{4}(2x+1)^{-3/2}$

16. Find the absolute minimum of $f(x) = x^4 - 4x^3 - 5$ on the interval $[-1, 2]$. 16. ____________

(a) -30 (b) 0 (c) -21 (d) No absolute minimum

17. Botanists, Inc., a consulting firm, monitors the monthly growth of an unusual plant. They determine that the growth (in inches) is given by

$$g(x) = 4x - x^2,$$

where x represents the average daily number of ounces of water the plant receives. Find the maximum monthly growth of the plant. 17. ____________

(a) 2 inches (b) 8 inches

(c) 4 inches (d) 6 inches

18. Find $\frac{dy}{dx}$, given $4x^2 - 7 = 3\sqrt{y} + \frac{2}{x^3}$. 18. ____________

(a) $\dfrac{4\sqrt{y}(4x^5 - 3)}{3x^4}$ (b) $\dfrac{4\sqrt{y}(4x^5 + 3)}{3x^4}$

(c) $\dfrac{4\sqrt{y}(4x^3 - 3)}{3x^2}$ (d) $\dfrac{4\sqrt{y}(4x^3 + 3)}{3x^2}$

19. If $xy = y + 6$, find $\frac{dy}{dt}$ if $\frac{dx}{dt} = -3$, $x = 4$, and $y = 2$. 19. ____________

(a) 2 (b) 0 (c) -2 (d) -4

20. Evaluate dy, given $y = 45 - 2x - 3x^2$, with $x = 3$ and $\Delta x = 0.02$. 20. ____________

(a) -0.4 (b) 0.4 (c) 0.32 (d) -0.32

21. Using differentials, approximate the volume of coating on a cube with 3-cm sides, if the coating is 0.02 cm thick. 21. ____________

(a) 0.54 cm^3 (b) 27.54 cm^3

(c) 26.46 cm^3 (d) 81.54 cm^3

22. Find $\int (4x^2 + 3x - 5)\,dx$. 22. ____________

(a) $\frac{4}{3}x^3 + \frac{3}{2}x^2 - 5 + C$ (b) $\frac{4}{3}x^3 + \frac{3}{2}x^2 - 5x$

(c) $\frac{3}{4}x^3 + \frac{3}{2}x^2 - 5 + C$ (d) $8x + 3$

23. Find $\int \frac{-3}{(2x+5)}\,dx.$ 23. ____________

(a) $-\frac{3}{2}\ln|2x+5|+C$ (b) $-3\ln|2x+5|+C$

(c) $-\frac{1}{6}\ln|2x+5|+C$ (d) $\frac{1}{2}\ln|2x+5|+C$

24. Evaluate $\int_0^1 2x\sqrt{4x^2+5}\,dx.$ 24. ____________

(a) $\frac{3}{8}$ (b) $\frac{27-5\sqrt{5}}{6}$

(c) $\frac{27-5\sqrt{5}}{8}$ (c) $\frac{27-5\sqrt{5}}{4}$

25. Find the area of the region between the x-axis and the graph of $f(x)=\sqrt{x+1}$ on the interval $[0,3]$. 25. ____________

(a) $\frac{14}{3}$ (b) 7 (c) $\frac{1}{4}$ (d) $\frac{21}{2}$

26. Find the area of the region enclosed by the graphs of $f(x)=9-x^2$ and $g(x)=x^2-9$. 26. ____________

(a) -36 (b) 36 (c) 0 (d) 72

27. Find $\int 3x^2e^{2x}\,dx.$ 27. ____________

(a) $3e^{x^2}+C$ (b) $\frac{3}{2}x^2e^{2x}-\frac{3}{2}xe^{2x}+\frac{3}{4}e^{2x}+C$

(c) $x^3e^{2x}+C$ (d) $3x^2e^{2x}-6xe^{2x}+6e^{2x}+C$

28. Evaluate $\int_1^4 9x^2\ln x\,dx.$ 28. ____________

(a) $192\ln 4-45$ (b) $192\ln 4-65$

(c) $192\ln 4-51$ (d) $192\ln 4-63$

29. Find the average value of the function $f(x)=\sqrt{3x+1}$ over the interval $[0, 8]$. 29. ____________

(a) $\frac{31}{3}$ (b) $\frac{248}{9}$ (c) $\frac{31}{9}$ (d) $\frac{248}{3}$

30. Find the volume of the solid of revolution formed by rotating the region bounded by $f(x) = \sqrt{x-1}$, $y = 0$, and $x = 10$ about the x-axis. 30. ________

(a) 40.5 (b) $\frac{81\pi}{2}$ (c) 18π (d) 40π

31. Evaluate $\int_{-\infty}^{-2} \frac{1}{x^3}\,dx$. 31. ________

(a) $-\frac{1}{8}$ (b) Diverges (c) $\frac{1}{64}$ (d) $-\frac{1}{64}$

32. Given $z = f(x, y) = x^2 - 3xy + 2y^3$, find $f_{yx}(0, -2)$. 32. ________

(a) -16 (b) 2 (c) -24 (d) -3

33. Which of the following applies to the function $f(x, y) = 2x^2 + 8y^3 - 12xy + 7$? 33. ________

(a) f has a relative maximum at $\left(\frac{9}{2}, \frac{3}{2}\right)$

(b) f has a relative minimum at $(0, 0)$

(c) f has a relative minimum at $\left(\frac{9}{2}, \frac{3}{2}\right)$

(d) f has a saddle point at $\left(\frac{9}{2}, \frac{3}{2}\right)$

34. Maximize $f(x, y) = x^2 y$, subject to the constraint $y + 4x = 84$. 34. ________

(a) 0 (b) 14 (c) 5488 (d) 3642

35. Find dz, given $z = \sqrt{x^2 + y^2}$, with $x = 3$, $y = 4$, $dx = -0.01$, and $dy = 0.02$. 35. ________

(a) 0.022 (b) 0.01 (c) 0.001 (d) 0.05

36. Evaluate $\int_0^2 \int_2^4 x^2 y\,dy\,dx$. 36. ________

(a) $\frac{112}{3}$ (b) 16 (c) 32 (d) 12

37. Find the general solution of the differential equation $\frac{dy}{dx} = \frac{e^{2x} - 4}{y^2}$. 37. ______________

(a) $y = \left(\frac{3}{2}e^{2x} - 12x + C\right)^{1/3}$ (b) $y = \frac{1}{2}e^{2x} - 4x + C$

(c) $y = \left(\frac{1}{2}e^{2x} - 4x + C\right)^{1/3}$ (d) $y^2 = e^{2x} - 4$

38. Find the particular solution of the differential equation
$\frac{dy}{dx} = 7 - 2x + 3x^2$; $y = -2$ when $x = 0$. 38. ______________

(a) $y = 7x - x^2 + x^3 + C$ (b) $y = 7x - x^2 + x^3 - 2$

(c) $y = -x^2 + x^3 + C$ (d) $y = 7x - x^2 + x^3 + 2 + C$

39. The marginal cost function for a particular commodity is $\frac{dy}{dx} = 10x - 7x^2$.
The fixed cost is $200. Find the cost function. 39. ______________

(a) $y = 200 + 5x^2 - 14x$ (b) $y = 5x^2 - 14x$

(c) $y = 5x^2 - \frac{7x^3}{3} + 200$ (c) $y = 10 - 14x$

40. The probability density function of a random variable is
defined by $f(x) = \frac{1}{5}$ for $[20, 25]$. Find $P(X \leq 22)$. 40. ______________

(a) 0.2 (b) 0.8 (c) 0.4 (d) 0.6

41. Find the standard deviation for the probability
density function $f(x) = 3x^{-4}$ on $[1, \infty)$. 41. ______________

(a) 1.5 (b) 0.866 (c) 0.75 (d) 0.67

42. The average height of a particular type of tree is 20 feet, with a
standard deviation of 2 feet. Assuming a normal distribution,
what is the probability that a tree of this kind will be taller than 17 feet? 42. ______________

(a) 0.0668 (b) 0.9332 (c) 0.8023 (d) 0.1977

43. Find the monthly house payment necessary to amortize a $150,000
loan at 7.2% for 30 years. 43. ______________

(a) $1018.18 (b) $975.34 (c) $1112.87 (d) $5478.44

44. Find the sum of the convergent geometric series $2 + \frac{1}{2} + \frac{1}{8} + \frac{1}{32} + \cdots$. 44. ______

(a) 2 (b) 8 (c) 4 (d) $\frac{8}{3}$

45. The nth term of the Taylor series expansion of $\ln(1 + \frac{x}{2})$ is given by which of the following? 45. ______

(a) $\frac{(-1)^n x^{n+1}}{(n+1) \cdot 2^{n+1}}$ (b) $\frac{x^{n+1}}{n+1}$ (c) $\frac{x^{n+1}}{(n+1) \cdot 2^{n+1}}$ (d) $\frac{(-1)^n x^{n+1}}{n+1}$

46. Evaluate $\lim_{x \to 0} \frac{-2e^{4x} + 2}{x}$. 46. ______

(a) -2 (b) -8 (c) 0 (d) The limit does not exist.

47. Find the derivative of $f(x) = \tan \sqrt{2x + 1}$. 47. ______

(a) $\frac{\sec^2 \sqrt{2x+1}}{\sqrt{2x+1}}$ (b) $\frac{\sec^2 \sqrt{2x+1}}{2}$

(c) $x \sec^2 \sqrt{2x+1}$ (d) $2x \sec^2 \sqrt{2x+1}$

48. Find the derivative of $y = x^2 \cos^3 x$. 48. ______

(a) $x \cos^2 x\,(2 \cos x + 3x)$ (b) $x \cos^2 x\,(2 \cos x - 3x \sin x)$

(c) $x \cos^2 x\,(2 \cos x - 3x)$ (d) $x \cos^2 x\,(2 \cos x + 3x \sin x)$

49. Find $\int \tan(2x) \sec^2(2x)\, dx$. 49. ______

(a) $\frac{1}{4} \tan^2(2x) + C$ (b) $\tan^2(2x) + C$

(c) $\frac{1}{4} \sec(2x) + C$ (d) $\sec(2x) + C$

50. Evaluate $\int_0^{\pi/2} (10 - 10 \sin^2 x \cos x)\, dx$. 50. ______

(a) $\frac{20}{3}$ (b) $5\pi - 10$

(c) $\frac{30\pi - 10}{3}$ (d) $\frac{15\pi - 10}{3}$

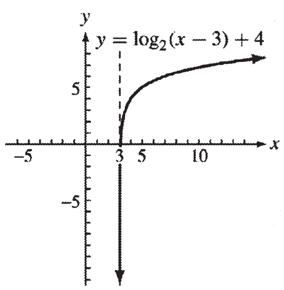
ANSWERS TO FINAL EXAMINATIONS

FINAL EXAMINATION, FORM A

1. (7.5,157.5)

2. $\log_2 d = a$

3.



4. 4

5. 5

6. $\frac{1}{4}$

7. $y' = 7xe^{3x}(2+3x)$

8. $y' = \dfrac{x+1-x\ln(3x)}{x(x+1)^2}$

9. 14

10. $y = 8x + 9$

11. $-\frac{12}{125}$

12. Increasing on $(-\infty, 2)$ and $(6, \infty)$; decreasing on $(2, 6)$

13. Relative maximum of 1 at -2; relative minimum of 13 at 4

14. (a) $(-\infty, 0)$ and $(2, \infty)$ (b) $(0, 2)$
(c) $(0, -5)$ and $(2, -21)$

15. $(x+4)e^x$

16. Absolute maximum of 0 at 0; absolute minimum of -16 at 2

17. 20,000

18. $\dfrac{dy}{dx} = \dfrac{3 - 14x^{1/2}y}{14x^{3/2} + 30x^{1/2}y^2}$

19. 12

20. $dy = -18x(2+x^2)^2\,dx$

21. 3π in.^{3}

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

23. $\frac{1}{8}\ln|x+9| + C$

24. $\frac{56}{9}$

25. $\frac{1}{2}(e^4 - 1)$

26. $\frac{10\sqrt{10}}{3} \approx 10.54$

27. $e^x(x^2 - 2x + 2) + C$

28. $\frac{3}{4}\left(3e^4 + 1\right) \approx 123.60$

29. 39

30. 120π

31. Converges; 1

32. -4

33. (a) None (b) -3 at $(-2, -2)$ (c) None

34. 5488 when $x = 14$ and $y = 28$

35. -0.12

36. $\frac{3}{2}e^4 - \frac{3}{2}e^2 \approx 70.81$

37. $y^2 = x + e^x + C$

38. $y = x^3 - \frac{7}{2}x^2 + 2x + 4$

39. $y = 4x^2 - 3x^3 + 20$

40. 0.5

41. (a) $\frac{3}{2}$ (b) 0.75 (c) 0.866

42. 0.0668

43. (a) $1 - 3x + \frac{9x^2}{2} - \frac{9x^3}{2} + \frac{27x^4}{8}$

(b) 0.9704

44. $\frac{15}{2}$

45. 0.78

46. 6

47. $2x\sec^2\left(x^2 + 1\right)$

48. $x^2 \sin x\,(3\sin x + 2x\cos x)$

49. $\frac{1}{3}\tan(3x + 1) + C$

50. $\frac{1}{64}$

FINAL EXAMINATION, FORM B

1.	(a)	**11.**	(c)	**21.**	(a)	**31.**	(a)	**41.**	(b)
2.	(d)	**12.**	(d)	**22.**	(c)	**32.**	(d)	**42.**	(b)
3.	(a)	**13.**	(b)	**23.**	(a)	**33.**	(c)	**43.**	(a)
4.	(c)	**14.**	(a)	**24.**	(b)	**34.**	(c)	**44.**	(d)
5.	(b)	**15.**	(b)	**25.**	(a)	**35.**	(b)	**45.**	(a)
6.	(c)	**16.**	(c)	**26.**	(d)	**36.**	(b)	**46.**	(b)
7.	(c)	**17.**	(c)	**27.**	(b)	**37.**	(a)	**47.**	(a)
8.	(c)	**18.**	(b)	**28.**	(d)	**38.**	(b)	**48.**	(b)
9.	(b)	**19.**	(a)	**29.**	(c)	**39.**	(c)	**49.**	(a)
10.	(a)	**20.**	(a)	**30.**	(b)	**40.**	(c)	**50.**	(d)

SOLUTIONS
TO
ALL EXERCISES

Chapter R

ALGEBRA REFERENCE

R.1 Polynomials

Your Turn 1

$$3(x^2 - 4x - 5) - 4(3x^2 - 5x - 7)$$
$$= 3x^2 - 12x - 15 - 12x^2 + 20x + 28$$
$$= -9x^2 + 8x + 13$$

Your Turn 2

$$(2x + 7)(3x - 1)$$
$$= (2x)(3x) + (2x)(-1) + (7)(3x) + (7)(-1)$$
$$= 6x^2 - 2x + 21x - 7$$
$$= 6x^2 + 19x - 7$$

Your Turn 3

$$(3y + 2)(4y^2 - 2y - 5)$$
$$= (3y)(4y^2 - 2y - 5) + (2)(4y^2 - 2y - 5)$$
$$= 12y^3 - 6y^2 - 15y + 8y^2 - 4y - 10$$
$$= 12y^3 + 2y^2 - 19y - 10$$

Your Turn 4

$$(3x + 2y)^3$$
$$= (3x + 2y)(3x + 2y)(3x + 2y)$$
$$= (9x^2 + 6xy + 6xy + 4y^2)(3x + 2y)$$
$$= (9x^2 + 12xy + 4y^2)(3x + 2y)$$
$$= 9x^2(3x + 2y) + 12xy(3x + 2y) + 4y^2(3x + 2y)$$
$$= 27x^3 + 18x^2y + 36x^2y + 24xy^2 + 12xy^2 + 8y^3$$
$$= 27x^3 + 54x^2y + 36xy^2 + 8y^3$$

R.1 Exercises

1. $(2x^2 - 6x + 11) + (-3x^2 + 7x - 2)$
$$= 2x^2 - 6x + 11 - 3x^2 + 7x - 2$$
$$= (2 - 3)x^2 + (7 - 6)x + (11 - 2)$$
$$= -x^2 + x + 9$$

2. $(-4y^2 - 3y + 8) - (2y^2 - 6y - 2)$
$$= (-4y^2 - 3y + 8) + (-2y^2 + 6y + 2)$$
$$= -4y^2 - 3y + 8 - 2y^2 + 6y + 2$$
$$= (-4y^2 - 2y^2) + (-3y + 6y) + (8 + 2)$$
$$= -6y^2 + 3y + 10$$

3. $\left(\frac{1}{2}z^2 + \frac{1}{3}z + \frac{2}{3}\right) + \left(z^2 + \frac{1}{2}z + \frac{4}{3}\right)$
$$= \left(\frac{1}{2}z^2 + z^2\right) + \left(\frac{1}{3}z + \frac{1}{2}z\right) + \left(\frac{2}{3} + \frac{4}{3}\right)$$
$$= \frac{3}{2}z^2 + \frac{5}{6}z + 2$$

4. $\left(\frac{2}{3}t^2 + \frac{3}{2}t + \frac{5}{6}\right) - \left(\frac{1}{6}t^2 + t + \frac{1}{6}\right)$
$$= \left(\frac{2}{3}t^2 + \frac{3}{2}t + \frac{5}{6}\right) + \left(-\frac{1}{6}t^2 - t - \frac{1}{6}\right)$$
$$= \left(\frac{2}{3}t^2 - \frac{1}{6}t^2\right) + \left(\frac{3}{2}t - t\right) + \left(\frac{5}{6} - \frac{1}{6}\right)$$
$$= \frac{1}{2}t^2 + \frac{1}{2}t + \frac{2}{3}$$

5. $-6(2q^2 + 4q - 3) + 4(-q^2 + 7q - 3)$
$$= (-12q^2 - 24q + 18) + (-4q^2 + 28q - 12)$$
$$= (-12q^2 - 4q^2) + (-24q + 28q) + (18 - 12)$$
$$= -16q^2 + 4q + 6$$

6. $2(3r^2 + 4r + 2) - 3(-r^2 + 4r - 5)$
$$= (6r^2 + 8r + 4) + (3r^2 - 12r + 15)$$
$$= (6r^2 + 3r^2) + (8r - 12r) + (4 + 15)$$
$$= 9r^2 - 4r + 19$$

7. $(0.613x^2 - 4.215x + 0.892) - 0.47(2x^2 - 3x + 5)$
$$= 0.613x^2 - 4.215x + 0.892 - 0.94x^2 + 1.41x - 2.35$$
$$= -0.327x^2 - 2.805x - 1.458$$

8. $0.5(5r^2 + 3.2r - 6) - (1.7r^2 - 2r - 1.5)$
$= (2.5r^2 + 1.6r - 3) + (-1.7r^2 + 2r + 1.5)$
$= (2.5r^2 - 1.7r^2) + (1.6r + 2r) + (-3 + 1.5)$
$= 0.8r^2 + 3.6r - 1.5$

9. $-9m(2m^2 + 3m - 1)$
$= -9m(2m^2) - 9m(3m) - 9m(-1)$
$= -18m^3 - 27m^2 + 9m$

10. $6x(-2x^3 + 5x + 6) = -12x^4 + 30x^2 + 36x$

11. $(3t - 2y)(3t + 5y)$
$= (3t)(3t) + (3t)(5y) + (-2y)(3t) + (-2y)(5y)$
$= 9t^2 + 15ty - 6ty - 10y^2$
$= 9t^2 + 9ty - 10y^2$

12. $(9k + q)(2k - q)$
$= (9k)(2k) + (9k)(-q) + (q)(2k) + (q)(-q)$
$= 18k^2 - 9kq + 2kq - q^2$
$= 18k^2 - 7kq - q^2$

13. $(2 - 3x)(2 + 3x)$
$= (2)(2) + (2)(3x) + (-3x)(2) + (-3x)(3x)$
$= 4 + 6x - 6x - 9x^2$
$= 4 - 9x^2$

14. $(6m + 5)(6m - 5)$
$= (6m)6m) + (6m)(-5) + (5)(6m) + (5)(-5)$
$= 36m^2 - 30m + 30m - 25$
$= 36m^2 - 25$

15. $\left(\frac{2}{5}y + \frac{1}{8}z\right)\left(\frac{3}{5}y + \frac{1}{2}z\right)$
$= \left(\frac{2}{5}y\right)\left(\frac{3}{5}y\right) + \left(\frac{2}{5}y\right)\left(\frac{1}{2}z\right) + \left(\frac{1}{8}z\right)\left(\frac{3}{5}y\right)$
$+ \left(\frac{1}{8}z\right)\left(\frac{1}{2}z\right)$
$= \frac{6}{25}y^2 + \frac{1}{5}yz + \frac{3}{40}yz + \frac{1}{16}z^2$
$= \frac{6}{25}y^2 + \left(\frac{8}{40} + \frac{3}{40}\right)yz + \frac{1}{16}z^2$
$= \frac{6}{25}y^2 + \frac{11}{40}yz + \frac{1}{16}z^2$

16. $\left(\frac{3}{4}r - \frac{2}{3}s\right)\left(\frac{5}{4}r + \frac{1}{3}s\right)$
$= \left(\frac{3}{4}r\right)\left(\frac{5}{4}r\right) + \left(\frac{3}{4}r\right)\left(\frac{1}{3}s\right) + \left(-\frac{2}{3}s\right)\left(\frac{5}{4}r\right)$
$+ \left(-\frac{2}{3}s\right)\left(\frac{1}{3}s\right)$
$= \frac{15}{16}r^2 + \frac{1}{4}rs - \frac{5}{6}rs - \frac{2}{9}s^2$
$= \frac{15}{16}r^2 - \frac{7}{12}rs - \frac{2}{9}s^2$

17. $(3p - 1)(9p^2 + 3p + 1)$
$= (3p - 1)(9p^2) + (3p - 1)(3p) + (3p - 1)(1)$
$= 3p(9p^2) - 1(9p^2) + 3p(3p)$
$- 1(3p) + 3p(1) - 1(1)$
$= 27p^3 - 9p^2 + 9p^2 - 3p + 3p - 1$
$= 27p^3 - 1$

18. $(3p + 2)(5p^2 + p - 4)$
$= (3p)(5p^2) + (3p)(p) + (3p)(-4)$
$+ (2)(5p^2) + (2)(p) + (2)(-4)$
$= 15p^3 + 3p^2 - 12p + 10p^2 + 2p - 8$
$= 15p^3 + 13p^2 - 10p - 8$

19. $(2m + 1)(4m^2 - 2m + 1)$
$= 2m(4m^2 - 2m + 1) + 1(4m^2 - 2m + 1)$
$= 8m^3 - 4m^2 + 2m + 4m^2 - 2m + 1$
$= 8m^3 + 1$

20. $(k + 2)(12k^3 - 3k^2 + k + 1)$
$= k(12k^3) + k(-3k^2) + k(k) + k(1)$
$+ 2(12k^3) + 2(-3k^2) + 2(k) + 2(1)$
$= 12k^4 - 3k^3 + k^2 + k + 24k^3 - 6k^2$
$+ 2k + 2$
$= 12k^4 + 21k^3 - 5k^2 + 3k + 2$

21. $(x + y + z)(3x - 2y - z)$
$= x(3x) + x(-2y) + x(-z) + y(3x) + y(-2y)$
$+ y(-z) + z(3x) + z(-2y) + z(-z)$
$= 3x^2 - 2xy - xz + 3xy - 2y^2 - yz + 3xz$
$- 2yz - z^2$
$= 3x^2 + xy + 2xz - 2y^2 - 3yz - z^2$

22. $(r + 2s - 3t)(2r - 2s + t)$
$$= r(2r) + r(-2s) + r(t) + 2s(2r) + 2s(-2s) + 2s(t) - 3t(2r) - 3t(-2s) - 3t(t)$$
$$= 2r^2 - 2rs + rt + 4rs + 2st - 6rt + 6st - 3t^2 + 2rt - st + t^2$$
$$= 2r^2 + 2rs - 5rt - 4s^2 + 8st - 3t^2$$

23. $(x + 1)(x + 2)(x + 3)$
$$= [x(x + 2) + 1(x + 2)](x + 3)$$
$$= [x^2 + 2x + x + 2](x + 3)$$
$$= [x^2 + 3x + 2](x + 3)$$
$$= x^2(x + 3) + 3x(x + 3) + 2(x + 3)$$
$$= x^3 + 3x^2 + 3x^2 + 9x + 2x + 6$$
$$= x^3 + 6x^2 + 11x + 6$$

24. $(x - 1)(x + 2)(x - 3)$
$$= [x(x + 2) + (-1)(x + 2)](x - 3)$$
$$= (x^2 + 2x - x - 2)(x - 3)$$
$$= (x^2 + x - 2)(x - 3)$$
$$= x^2(x - 3) + x(x - 3) + (-2)(x - 3)$$
$$= x^3 - 3x^2 + x^2 - 3x - 2x + 6$$
$$= x^3 - 2x^2 - 5x + 6$$

25. $(x + 2)^2 = (x + 2)(x + 2)$
$$= x(x + 2) + 2(x + 2)$$
$$= x^2 + 2x + 2x + 4$$
$$= x^2 + 4x + 4$$

26. $(2a - 4b)^2 = (2a - 4b)(2a - 4b)$
$$= 2a(2a - 4b) - 4b(2a - 4b)$$
$$= 4a^2 - 8ab - 8ab + 16b^2$$
$$= 4a^2 - 16ab + 16b^2$$

27. $(x - 2y)^3$
$$= [(x - 2y)(x - 2y)](x - 2y)$$
$$= (x^2 - 2xy - 2xy + 4y^2)(x - 2y)$$
$$= (x^2 - 4xy + 4y^2)(x - 2y)$$
$$= (x^2 - 4xy + 4y^2)x + (x^2 - 4xy + 4y^2)(-2y)$$
$$= x^3 - 4x^2y + 4xy^2 - 2x^2y + 8xy^2 - 8y^3$$
$$= x^3 - 6x^2y + 12xy^2 - 8y^3$$

28. $(3x + y)^3 = (3x + y)(3x + y)^2$
$$= (3x + y)(9x^2 + 6xy + y^2)$$
$$= 27x^3 + 18x^2y + 3xy^2 + 9x^2y + 6xy^2 + y^3$$
$$= 27x^3 + 27x^2y + 9xy^2 + y^3$$

R.2 Factoring

Your Turn 1

Factor $4z^4 + 4z^3 + 18z^2$.

$$4z^4 + 4z^3 + 18z^2 = (2z^2) \cdot 2z^2 + (2z^2) \cdot 2z + (2z^2) \cdot 9 = (2z^2)(2z^2 + 2z + 9)$$

Your Turn 2

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

since $(2)(-5) = -10$ and $-5 + 2 = -3$.

Your Turn 3

Factor $6a^2 + 5ab - 4b^2$.

$6a^2 + 5ab - 4b^2 = (2a - b)(3a + 4b)$

R.2 Exercises

1. $7a^3 + 14a^2 = 7a^2 \cdot a + 7a^2 \cdot 2$
$$= 7a^2(a + 2)$$

2. $3y^3 + 24y^2 + 9y = 3y \cdot y^2 + 3y \cdot 8y + 3y \cdot 3$
$$= 3y(y^2 + 8y + 3)$$

3. $13p^4q^2 - 39p^3q + 26p^2q^2$
$$= 13p^2q \cdot p^2q - 13p^2q \cdot 3p + 13p^2q \cdot 2q$$
$$= 13p^2q(p^2q - 3p + 2q)$$

4. $60m^4 - 120m^3n + 50m^2n^2$
$$= 10m^2 \cdot 6m^2 - 10m^2 \cdot 12mn + 10m^2 \cdot 5n^2$$
$$= 10m^2(6m^2 - 12mn + 5n^2)$$

5. $m^2 - 5m - 14 = (m - 7)(m + 2)$
since $(-7)(2) = -14$ and $-7 + 2 = -5$.

6. $x^2 + 4x - 5 = (x + 5)(x - 1)$
since $5(-1) = -5$ and $-1 + 5 = 4$.

7. $z^2 + 9z + 20 = (z + 4)(z + 5)$
since $4 \cdot 5 = 20$ and $4 + 5 = 9$.

8. $b^2 - 8b + 7 = (b - 7)(b - 1)$
since $(-7)(-1) = 7$ and $-7 + (-1) = -8$.

9. $a^2 - 6ab + 5b^2 = (a - b)(a - 5b)$
since $(-b)(-5b) = 5b^2$ and $-b + (-5b) = -6b$.

10. $s^2 + 2st - 35t^2 = (s - 5t)(s + 7t)$
since $(-5t)(7t) = -35t^2$ and $7t + (-5t) = 2t$.

11. $y^2 - 4yz - 21z^2 = (y + 3z)(y - 7z)$
since $(3z)(-7z) = -21z^2$ and $3z + (-7z) = -4z$.

12. $3x^2 + 4x - 7$
The possible factors of $3x^2$ are $3x$ and x and the possible factors of -7 are -7 and 1, or 7 and -1. Try various combinations until one works.
$3x^2 + 4x - 7 = (3x + 7)(x - 1)$

13. $3a^2 + 10a + 7$
The possible factors of $3a^2$ are $3a$ and a and the possible factors of 7 are 7 and 1. Try various combinations until one works.
$3a^2 + 10a + 7 = (a + 1)(3a + 7)$

14. $15y^2 + y - 2 = (5y + 2)(3y - 1)$

15. $21m^2 + 13mn + 2n^2 = (7m + 2n)(3m + n)$

16. $$6a^2 - 48a - 120 = 6(a^2 - 8a - 20) = 6(a - 10)(a + 2)$$

17. $$3m^3 + 12m^2 + 9m = 3m(m^2 + 4m + 3) = 3m(m + 1)(m + 3)$$

18. $$4a^2 + 10a + 6 = 2(2a^2 + 5a + 3) = 2(2a + 3)(a + 1)$$

19. $$24a^4 + 10a^3b - 4a^2b^2 = 2a^2(12a^2 + 5ab - 2b^2) = 2a^2(4a - b)(3a + 2b)$$

20. $$24x^4 + 36x^3y - 60x^2y^2 = 12x^2(2x^2 + 3xy - 5y^2) = 12x^2(x - y)(2x + 5y)$$

21. $$x^2 - 64 = x^2 - 8^2 = (x + 8)(x - 8)$$

22. $$9m^2 - 25 = (3m)^2 - (5)^2 = (3m + 5)(3m - 5)$$

23. $$10x^2 - 160 = 10(x^2 - 16) = 10(x^2 - 4^2) = 10(x + 4)(x - 4)$$

24. $9x^2 + 64$ is the *sum* of two perfect squares. It cannot be factored. It is prime.

25. $$z^2 + 14zy + 49y^2 = z^2 + 2 \cdot 7zy + 7^2y^2 = (z + 7y)^2$$

26. $$s^2 - 10st + 25t^2 = s^2 - 2 \cdot 5st + (5t)^2 = (s - 5t)^2$$

27. $$9p^2 - 24p + 16 = (3p)^2 - 2 \cdot 3p \cdot 4 + 4^2 = (3p - 4)^2$$

28. $$a^3 - 216 = a^3 - 6^3 = (a - 6)[(a)^2 + (a)(6) + (6)^2] = (a - 6)(a^2 + 6a + 36)$$

29. $$27r^3 - 64s^3 = (3r)^3 - (4s)^3 = (3r - 4s)(9r^2 + 12rs + 16s^2)$$

30. $$3m^3 + 375 = 3(m^3 + 125) = 3(m^3 + 5^3) = 3(m + 5)(m^2 - 5m + 25)$$

31. $$x^4 - y^4 = (x^2)^2 - (y^2)^2 = (x^2 + y^2)(x^2 - y^2) = (x^2 + y^2)(x + y)(x - y)$$

32. $$16a^4 - 81b^4 = (4a^2)^2 - (9b^2)^2 = (4a^2 + 9b^2)(4a^2 - 9b^2) = (4a^2 + 9b^2)[(2a)^2 - (3b)^2] = (4a^2 + 9b^2)(2a + 3b)(2a - 3b)$$

R.3 Rational Expressions

Your Turn 1

Write in lowest terms $\frac{z^2 + 5z + 6}{2z^2 + 7z + 3}$.

$$\frac{z^2 + 5z + 6}{2z^2 + 7z + 3} = \frac{(z + 3)(z + 2)}{(z + 3)(2z + 1)} = \frac{z + 2}{2z + 1}$$

Your Turn 2

Perform each of the following operations.

(a) $$\frac{z^2+5z+6}{2z^2-5z-3}\cdot\frac{2z^2-z-1}{z^2+2z-3}$$
$$=\frac{(z+2)(z+3)}{(2z+1)(z-3)}\cdot\frac{(2z+1)(z-1)}{(z+3)(z-1)}$$
$$=\frac{(z+2)\cancel{(z+3)}\cancel{(2z+1)}\cancel{(z-1)}}{\cancel{(2z+1)}(z-3)\cancel{(z+3)}\cancel{(z-1)}}$$
$$=\frac{z+2}{z-3}$$

(b) $$\frac{a-3}{a^2+3a+2}+\frac{5a}{a^2-4}$$
$$=\frac{a-3}{(a+2)(a+1)}+\frac{5a}{(a-2)(a+2)}$$
$$=\frac{a-3}{(a+2)(a+1)}\cdot\frac{(a-2)}{(a-2)}+\frac{5a}{(a-2)(a+2)}\cdot\frac{(a+1)}{(a+1)}$$
$$=\frac{(a^2-5a+6)+(5a^2+5a)}{(a-2)(a+2)(a+1)}$$
$$=\frac{6a^2+6}{(a-2)(a+2)(a+1)}$$
$$=\frac{6(a^2+1)}{(a-2)(a+2)(a+1)}$$

R.3 Exercises

1. $$\frac{5v^2}{35v}=\frac{5\cdot v\cdot v}{5\cdot 7\cdot v}=\frac{v}{7}$$

2. $$\frac{25p^3}{10p^2}=\frac{5\cdot 5\cdot p\cdot p\cdot p}{2\cdot 5\cdot p\cdot p}=\frac{5p}{2}$$

3. $$\frac{8k+16}{9k+18}=\frac{8(k+2)}{9(k+2)}=\frac{8}{9}$$

4. $$\frac{2(t-15)}{(t-15)(t+2)}=\frac{2}{t+2}$$

5. $$\frac{4x^3-8x^2}{4x^2}=\frac{4x^2(x-2)}{4x^2}=x-2$$

6. $$\frac{36y^2+72y}{9y}=\frac{36y(y+2)}{9y}=\frac{9\cdot 4\cdot y(y+2)}{9\cdot y}=4(y+2)$$

7. $$\frac{m^2-4m+4}{m^2+m-6}=\frac{(m-2)(m-2)}{(m-2)(m+3)}=\frac{m-2}{m+3}$$

8. $$\frac{r^2-r-6}{r^2+r-12}=\frac{(r-3)(r+2)}{(r+4)(r-3)}=\frac{r+2}{r+4}$$

9. $$\frac{3x^2+3x-6}{x^2-4}=\frac{3(x+2)(x-1)}{(x+2)(x-2)}=\frac{3(x-1)}{x-2}$$

10. $$\frac{z^2-5z+6}{z^2-4}=\frac{(z-3)(z-2)}{(z+2)(z-2)}=\frac{z-3}{z+2}$$

11. $$\frac{m^4-16}{4m^2-16}=\frac{(m^2+4)(m+2)(m-2)}{4(m+2)(m-2)}=\frac{m^2+4}{4}$$

12. $$\frac{6y^2+11y+4}{3y^2+7y+4}=\frac{(3y+4)(2y+1)}{(3y+4)(y+1)}=\frac{2y+1}{y+1}$$

13. $$\frac{9k^2}{25}\cdot\frac{5}{3k}=\frac{3\cdot 3\cdot 5k^2}{5\cdot 5\cdot 3k}=\frac{3k^2}{5k}=\frac{3k}{5}$$

14. $$\frac{15p^3}{9p^2}\div\frac{6p}{10p^2}=\frac{15p^3}{9p^2}\cdot\frac{10p^2}{6p}=\frac{150p^5}{54p^3}=\frac{25\cdot 6p^5}{9\cdot 6p^3}=\frac{25p^2}{9}$$

15. $$\frac{3a+3b}{4c}\cdot\frac{12}{5(a+b)}=\frac{3(a+b)}{4c}\cdot\frac{3\cdot 4}{5(a+b)}=\frac{3\cdot 3}{c\cdot 5}=\frac{9}{5c}$$

16. $$\frac{a-3}{16}\div\frac{a-3}{32}=\frac{a-3}{16}\cdot\frac{32}{a-3}=\frac{a-3}{16}\cdot\frac{16\cdot 2}{a-3}=\frac{2}{1}=2$$

17. $\frac{2k-16}{6} \div \frac{4k-32}{3} = \frac{2k-16}{6} \cdot \frac{3}{4k-32}$
$= \frac{2(k-8)}{6} \cdot \frac{3}{4(k-8)}$
$= \frac{1}{4}$

18. $\frac{9y-18}{6y+12} \cdot \frac{3y+6}{15y-30} = \frac{9(y-2)}{6(y+2)} \cdot \frac{3(y+2)}{15(y-2)}$
$= \frac{27}{90} = \frac{3 \cdot 3}{10 \cdot 3} = \frac{3}{10}$

19. $\frac{4a+12}{2a-10} \div \frac{a^2-9}{a^2-a-20}$
$= \frac{4(a+3)}{2(a-5)} \cdot \frac{(a-5)(a+4)}{(a-3)(a+3)}$
$= \frac{2(a+4)}{a-3}$

20. $\frac{6r-18}{9r^2+6r-24} \cdot \frac{12r-16}{4r-12}$
$= \frac{6(r-3)}{3(3r^2+2r-8)} \cdot \frac{4(3r-4)}{4(r-3)}$
$= \frac{6(r-3)}{3(3r-4)(r+2)} \cdot \frac{4(3r-4)}{4(r-3)}$
$= \frac{6}{3(r+2)} = \frac{2}{r+2}$

21. $\frac{k^2+4k-12}{k^2+10k+24} \cdot \frac{k^2+k-12}{k^2-9}$
$= \frac{(k+6)(k-2)}{(k+6)(k+4)} \cdot \frac{(k+4)(k-3)}{(k+3)(k-3)}$
$= \frac{k-2}{k+3}$

22. $\frac{m^2+3m+2}{m^2+5m+4} \div \frac{m^2+5m+6}{m^2+10m+24}$
$= \frac{m^2+3m+2}{m^2+5m+4} \cdot \frac{m^2+10m+24}{m^2+5m+6}$
$= \frac{(m+1)(m+2)}{(m+4)(m+1)} \cdot \frac{(m+6)(m+4)}{(m+3)(m+2)}$
$= \frac{m+6}{m+3}$

23. $\frac{2m^2-5m-12}{m^2-10m+24} \div \frac{4m^2-9}{m^2-9m+18}$
$= \frac{2m^2-5m-12}{m^2-10m+24} \cdot \frac{m^2-9m+18}{4m^2-9}$
$= \frac{(2m+3)(m-4)(m-6)(m-3)}{(m-6)(m-4)(2m-3)(2m+3)}$
$= \frac{m-3}{2m-3}$

24. $\frac{4n^2+4n-3}{6n^2-n-15} \cdot \frac{8n^2+32n+30}{4n^2+16n+15}$
$= \frac{(2n+3)(2n-1)}{(2n+3)(3n-5)} \cdot \frac{2(2n+3)(2n+5)}{(2n+3)(2n+5)}$
$= \frac{2(2n-1)}{3n-5}$

25. $\frac{a+1}{2} - \frac{a-1}{2} = \frac{(a+1)-(a-1)}{2}$
$= \frac{a+1-a+1}{2}$
$= \frac{2}{2} = 1$

26. $\frac{3}{p} + \frac{1}{2}$

Multiply the first term by $\frac{2}{2}$ and the second by $\frac{p}{p}$.

$\frac{2 \cdot 3}{2 \cdot p} + \frac{p \cdot 1}{p \cdot 2} = \frac{6}{2p} + \frac{p}{2p} = \frac{6+p}{2p}$

27. $\frac{6}{5y} - \frac{3}{2} = \frac{6 \cdot 2}{5y \cdot 2} - \frac{3 \cdot 5y}{2 \cdot 5y} = \frac{12-15y}{10y}$

28. $\frac{1}{6m} + \frac{2}{5m} + \frac{4}{m} = \frac{5 \cdot 1}{5 \cdot 6m} + \frac{6 \cdot 2}{6 \cdot 5m} + \frac{30 \cdot 4}{30 \cdot m}$
$= \frac{5}{30m} + \frac{12}{30m} + \frac{120}{30m}$
$= \frac{5+12+120}{30m}$
$= \frac{137}{30m}$

29. $\frac{1}{m-1} + \frac{2}{m} = \frac{m}{m}\left(\frac{1}{m-1}\right) + \frac{m-1}{m-1}\left(\frac{2}{m}\right)$
$= \frac{m+2m-2}{m(m-1)}$
$= \frac{3m-2}{m(m-1)}$

30. $\dfrac{5}{2r+3}-\dfrac{2}{r}=\dfrac{5r}{r(2r+3)}-\dfrac{2(2r+3)}{r(2r+3)}$
$=\dfrac{5r-2(2r+3)}{r(2r+3)}=\dfrac{5r-4r-6}{r(2r+3)}$
$=\dfrac{r-6}{r(2r+3)}$

31. $\dfrac{8}{3(a-1)}+\dfrac{2}{a-1}=\dfrac{8}{3(a-1)}+\dfrac{3}{3}\left(\dfrac{2}{a-1}\right)$
$=\dfrac{8+6}{3(a-1)}$
$=\dfrac{14}{3(a-1)}$

32. $\dfrac{2}{5(k-2)}+\dfrac{3}{4(k-2)}=\dfrac{4\cdot 2}{4\cdot 5(k-2)}+\dfrac{5\cdot 3}{5\cdot 4(k-2)}$
$=\dfrac{8}{20(k-2)}+\dfrac{15}{20(k-2)}$
$=\dfrac{8+15}{20(k-2)}$
$=\dfrac{23}{20(k-2)}$

33. $\dfrac{4}{x^2+4x+3}+\dfrac{3}{x^2-x-2}$
$=\dfrac{4}{(x+3)(x+1)}+\dfrac{3}{(x-2)(x+1)}$
$=\dfrac{4(x-2)}{(x-2)(x+3)(x+1)}$
$+\dfrac{3(x+3)}{(x-2)(x+3)(x+1)}$
$=\dfrac{4(x-2)+3(x+3)}{(x-2)(x+3)(x+1)}$
$=\dfrac{4x-8+3x+9}{(x-2)(x+3)(x+1)}$
$=\dfrac{7x+1}{(x-2)(x+3)(x+1)}$

34. $\dfrac{y}{y^2+2y-3}-\dfrac{1}{y^2+4y+3}$
$=\dfrac{y}{(y+3)(y-1)}-\dfrac{1}{(y+3)(y+1)}$
$=\dfrac{y(y+1)}{(y+3)(y+1)(y-1)}$
$-\dfrac{1(y-1)}{(y+3)(y+1)(y-1)}$
$=\dfrac{y(y+1)-(y-1)}{(y+3)(y+1)(y-1)}$
$=\dfrac{y^2+y-y+1}{(y+3)(y+1)(y-1)}$
$=\dfrac{y^2+1}{(y+3)(y+1)(y-1)}$

35. $\dfrac{3k}{2k^2+3k-2}-\dfrac{2k}{2k^2-7k+3}$
$=\dfrac{3k}{(2k-1)(k+2)}-\dfrac{2k}{(2k-1)(k-3)}$
$=\left(\dfrac{k-3}{k-3}\right)\dfrac{3k}{(2k-1)(k+2)}$
$-\left(\dfrac{k+2}{k+2}\right)\dfrac{2k}{(2k-1)(k-3)}$
$=\dfrac{(3k^2-9k)-(2k^2+4k)}{(2k-1)(k+2)(k-3)}$
$=\dfrac{k^2-13k}{(2k-1)(k+2)(k-3)}$
$=\dfrac{k(k-13)}{(2k-1)(k+2)(k-3)}$

36. $\dfrac{4m}{3m^2+7m-6}-\dfrac{m}{3m^2-14m+8}$
$=\dfrac{4m}{(3m-2)(m+3)}-\dfrac{m}{(3m-2)(m-4)}$
$=\dfrac{4m(m-4)}{(3m-2)(m+3)(m-4)}$
$-\dfrac{m(m+3)}{(3m-2)(m-4)(m+3)}$
$=\dfrac{4m(m-4)-m(m+3)}{(3m-2)(m-4)(m+3)}$
$=\dfrac{4m^2-16m-m^2-3m}{(3m-2)(m+3)(m-4)}$
$=\dfrac{3m^2-19m}{(3m-2)(m+3)(m-4)}$
$=\dfrac{m(3m-19)}{(3m-2)(m+3)(m-4)}$

37. $\dfrac{2}{a+2}+\dfrac{1}{a}+\dfrac{a-1}{a^2+2a}$

$$=\frac{2}{a+2}+\frac{1}{a}+\frac{a-1}{a(a+2)}$$
$$=\left(\frac{a}{a}\right)\frac{2}{a+2}+\left(\frac{a+2}{a+2}\right)\frac{1}{a}+\frac{a-1}{a(a+2)}$$
$$=\frac{2a+a+2+a-1}{a(a+2)}$$
$$=\frac{4a+1}{a(a+2)}$$

38. $\dfrac{5x+2}{x^2-1}+\dfrac{3}{x^2+x}-\dfrac{1}{x^2-x}$

$$=\frac{5x+2}{(x+1)(x-1)}+\frac{3}{x(x+1)}-\frac{1}{x(x-1)}$$
$$=\left(\frac{x}{x}\right)\left(\frac{5x+2}{(x+1)(x-1)}\right)+\left(\frac{x-1}{x-1}\right)\left(\frac{3}{x(x+1)}\right)-\left(\frac{x+1}{x+1}\right)\left(\frac{1}{x(x-1)}\right)$$
$$=\frac{x(5x+2)+(x-1)(3)-(x+1)(1)}{x(x+1)(x-1)}$$
$$=\frac{5x^2+2x+3x-3-x-1}{x(x+1)(x-1)}$$
$$=\frac{5x^2+4x-4}{x(x+1)(x-1)}$$

R.4 Equations

Your Turn 1

Solve $3x-7=4(5x+2)-7x$.

$$3x-7=20x+8-7x$$
$$3x-7=13x+8$$
$$-10x=15$$
$$x=-\frac{15}{10}$$
$$x=-\frac{3}{2}$$

Your Turn 2

Solve $2m^2+7m=15$.

$$2m^2+7m-15=0$$
$$(2m-3)(m+5)=0$$
$$2m-3=0 \quad\text{or}\quad m+5=0$$
$$m=\frac{3}{2} \quad\text{or}\quad m=-5$$

Your Turn 3

Solve $z^2+6=8z$.

$$z^2-8z+6=0$$

Use the quadratic formula with $a=1$, $b=-8$, and $c=6$.

$$z=\frac{-(-8)\pm\sqrt{(-8)^2-4(1)(6)}}{2(1)}$$
$$=\frac{8\pm\sqrt{64-24}}{2}$$
$$=\frac{8\pm\sqrt{40}}{2}$$
$$=\frac{8\pm\sqrt{4\cdot 10}}{2}$$
$$=\frac{8\pm 2\sqrt{10}}{2}$$
$$=4\pm\sqrt{10}$$

Your Turn 4

Solve $\dfrac{1}{x^2-4}+\dfrac{2}{x-2}=\dfrac{1}{x}$.

$$\frac{1}{(x-2)(x+2)}+\frac{2}{x-2}=\frac{1}{x}$$
$$(x-2)(x+2)(x)\cdot\frac{1}{(x-2)(x+2)}+(x-2)(x+2)(x)\cdot\frac{2}{x-2}=(x-2)(x+2)(x)\cdot\frac{1}{x}$$
$$x+2x^2+4x=x^2-4$$
$$x^2+5x+4=0$$
$$(x+1)(x+4)=0$$
$$x=-1 \quad\text{or}\quad x=-4$$

Neither of these values makes a denominator equal to zero, so both are solutions.

R.4 Exercises

1. $2x+8=x-4$

$$x+8=-4$$
$$x=-12$$

The solution is –12.

2. $5x+2=8-3x$

$$8x+2=8$$
$$8x=6$$
$$x=\frac{3}{4}$$

The solution is $\frac{3}{4}$.

3.
$$\begin{aligned} 0.2m - 0.5 &= 0.1m + 0.7 \\ 10(0.2m - 0.5) &= 10(0.1m + 0.7) \\ 2m - 5 &= m + 7 \\ m - 5 &= 7 \\ m &= 12 \end{aligned}$$
The solution is 12.

4. $\frac{2}{3}k - k + \frac{3}{8} = \frac{1}{2}$

Multiply both sides of the equation by 24.
$$\begin{aligned} 24\left(\frac{2}{3}k\right) - 24(k) + 24\left(\frac{3}{8}\right) &= 24\left(\frac{1}{2}\right) \\ 16k - 24k + 9 &= 12 \\ -8k + 9 &= 12 \\ -8k &= 3 \\ k &= -\frac{3}{8} \end{aligned}$$
The solution is $-\frac{3}{8}$.

5.
$$\begin{aligned} 3r + 2 - 5(r + 1) &= 6r + 4 \\ 3r + 2 - 5r - 5 &= 6r + 4 \\ -3 - 2r &= 6r + 4 \\ -3 &= 8r + 4 \\ -7 &= 8r \\ -\frac{7}{8} &= r \end{aligned}$$
The solution is $-\frac{7}{8}$.

6.
$$\begin{aligned} 5(a + 3) + 4a - 5 &= -(2a - 4) \\ 5a + 15 + 4a - 5 &= -2a + 4 \\ 9a + 10 &= -2a + 4 \\ 11a + 10 &= 4 \\ 11a &= -6 \\ a &= -\frac{6}{11} \end{aligned}$$
The solution is $-\frac{6}{11}$.

7.
$$\begin{aligned} 2[3m - 2(3 - m) - 4] &= 6m - 4 \\ 2[3m - 6 + 2m - 4] &= 6m - 4 \\ 2[5m - 10] &= 6m - 4 \\ 10m - 20 &= 6m - 4 \\ 4m - 20 &= -4 \\ 4m &= 16 \\ m &= 4 \end{aligned}$$
The solution is 4.

8.
$$\begin{aligned} 4[2p - (3 - p) + 5] &= -7p - 2 \\ 4[2p - 3 + p + 5] &= -7p - 2 \\ 4[3p + 2] &= -7p - 2 \\ 12p + 8 &= -7p - 2 \\ 19p + 8 &= -2 \\ 19p &= -10 \\ p &= -\frac{10}{19} \end{aligned}$$
The solution is $-\frac{10}{19}$.

9.
$$\begin{aligned} x^2 + 5x + 6 &= 0 \\ (x + 3)(x + 2) &= 0 \\ x + 3 = 0 \quad &\text{or} \quad x + 2 = 0 \\ x = -3 \quad &\text{or} \quad x = -2 \end{aligned}$$
The solutions are -3 and -2.

10.
$$\begin{aligned} x^2 &= 3 + 2x \\ x^2 - 2x - 3 &= 0 \\ (x - 3)(x + 1) &= 0 \\ x - 3 = 0 \quad &\text{or} \quad x + 1 = 0 \\ x = 3 \quad &\text{or} \quad x = -1 \end{aligned}$$
The solutions are 3 and -1.

11.
$$\begin{aligned} m^2 &= 14m - 49 \\ m^2 - 14m + 49 &= 0 \\ (m)^2 - 2(7m) + (7)^2 &= 0 \\ (m - 7)^2 &= 0 \\ m - 7 &= 0 \\ m &= 7 \end{aligned}$$
The solution is 7.

12.
$$\begin{aligned} 2k^2 - k &= 10 \\ 2k^2 - k - 10 &= 0 \\ (2k - 5)(k + 2) &= 0 \\ 2k - 5 = 0 \quad &\text{or} \quad k + 2 = 0 \\ k = \frac{5}{2} \quad &\text{or} \quad k = -2 \end{aligned}$$
The solutions are $\frac{5}{2}$ and -2.

13.
$$\begin{aligned} 12x^2 - 5x &= 2 \\ 12x^2 - 5x - 2 &= 0 \\ (4x + 1)(3x - 2) &= 0 \\ 4x + 1 = 0 \quad &\text{or} \quad 3x - 2 = 0 \\ 4x = -1 \quad &\text{or} \quad 3x = 2 \\ x = -\frac{1}{4} \quad &\text{or} \quad x = \frac{2}{3} \end{aligned}$$
The solutions are $-\frac{1}{4}$ and $\frac{2}{3}$.

14. $m(m-7) = -10$

$m^2 - 7m + 10 = 0$

$(m-5)(m-2) = 0$

$m - 5 = 0$ or $m - 2 = 0$

$m = 5$ or $m = 2$

The solutions are 5 and 2.

15. $4x^2 - 36 = 0$

Divide both sides of the equation by 4.

$x^2 - 9 = 0$

$(x+3)(x-3) = 0$

$x + 3 = 0$ or $x - 3 = 0$

$x = -3$ or $x = 3$

The solutions are -3 and 3.

16. $z(2z+7) = 4$

$2z^2 + 7z - 4 = 0$

$(2z-1)(z+4) = 0$

$2z - 1 = 0$ or $z + 4 = 0$

$z = \frac{1}{2}$ or $z = -4$

The solutions are $\frac{1}{2}$ and -4.

17. $12y^2 - 48y = 0$

$12y(y) - 12y(4) = 0$

$12y(y-4) = 0$

$12y = 0$ or $y - 4 = 0$

$y = 0$ or $y = 4$

The solutions are 0 and 4.

18. $3x^2 - 5x + 1 = 0$

Use the quadratic formula.

$$x = \frac{-(-5) \pm \sqrt{(-5)^2 - 4(3)(1)}}{2(3)}$$

$$= \frac{5 \pm \sqrt{25 - 12}}{6}$$

$$x = \frac{5 + \sqrt{13}}{6} \quad \text{or} \quad x = \frac{5 - \sqrt{13}}{6}$$

$$\approx 1.4343 \qquad \approx 0.2324$$

The solutions are $\frac{5+\sqrt{13}}{6} \approx 1.4343$ and $\frac{5-\sqrt{13}}{6} \approx 0.2324$.

19. $2m^2 - 4m = 3$

$2m^2 - 4m - 3 = 0$

$$m = \frac{-(-4) \pm \sqrt{(-4)^2 - 4(2)(-3)}}{2(2)}$$

$$= \frac{4 \pm \sqrt{40}}{4} = \frac{4 \pm \sqrt{4 \cdot 10}}{4}$$

$$= \frac{4 \pm \sqrt{4}\sqrt{10}}{4}$$

$$= \frac{4 \pm 2\sqrt{10}}{4} = \frac{2 \pm \sqrt{10}}{2}$$

The solutions are $\frac{2+\sqrt{10}}{2} \approx 2.5811$ and $\frac{2-\sqrt{10}}{2} \approx -0.5811$.

20. $p^2 + p - 1 = 0$

$$p = \frac{-1 \pm \sqrt{1^2 - 4(1)(-1)}}{2(1)}$$

$$= \frac{-1 \pm \sqrt{5}}{2}$$

The solutions are $\frac{-1+\sqrt{5}}{2} \approx 0.6180$ and $\frac{-1-\sqrt{5}}{2} \approx -1.6180$.

21. $k^2 - 10k = -20$

$k^2 - 10k + 20 = 0$

$$k = \frac{-(-10) \pm \sqrt{(-10)^2 - 4(1)(20)}}{2(1)}$$

$$k = \frac{10 \pm \sqrt{100 - 80}}{2}$$

$$k = \frac{10 \pm \sqrt{20}}{2}$$

$$k = \frac{10 \pm \sqrt{4}\sqrt{5}}{2}$$

$$k = \frac{10 \pm 2\sqrt{5}}{2}$$

$$k = \frac{2(5 \pm \sqrt{5})}{2}$$

$$k = 5 \pm \sqrt{5}$$

The solutions are $5 + \sqrt{5} \approx 7.2361$ and $5 - \sqrt{5} \approx 2.7639$.

22. $5x^2 - 8x + 2 = 0$

$$x = \frac{-(-8) \pm \sqrt{(-8)^2 - 4(5)(2)}}{2(5)}$$
$$= \frac{8 \pm \sqrt{24}}{10}$$
$$= \frac{8 \pm \sqrt{4 \cdot 6}}{10}$$
$$= \frac{8 \pm \sqrt{4}\sqrt{6}}{10} = \frac{8 \pm 2\sqrt{6}}{10}$$
$$= \frac{4 \pm \sqrt{6}}{5}$$

The solutions are $\frac{4+\sqrt{6}}{5} \approx 1.2899$ and $\frac{4-\sqrt{6}}{5} \approx 0.3101$.

23. $2r^2 - 7r + 5 = 0$

$(2r - 5)(r - 1) = 0$

$2r - 5 = 0$ or $r - 1 = 0$

$2r = 5$

$r = \frac{5}{2}$ or $r = 1$

The solutions are $\frac{5}{2}$ and 1.

24. $2x^2 - 7x + 30 = 0$

$$x = \frac{-(-7) \pm \sqrt{(-7)^2 - 4(2)(30)}}{2(2)}$$
$$x = \frac{7 \pm \sqrt{49 - 240}}{4}$$
$$x = \frac{7 \pm \sqrt{-191}}{4}$$

Since there is a negative number under the radical sign, $\sqrt{-191}$ is not a real number. Thus, there are no real number solutions.

25. $3k^2 + k = 6$

$3k^2 + k - 6 = 0$

$$k = \frac{-1 \pm \sqrt{1 - 4(3)(-6)}}{2(3)}$$
$$= \frac{-1 \pm \sqrt{73}}{6}$$

The solutions are $\frac{-1+\sqrt{73}}{6} \approx 1.2573$ and $\frac{-1-\sqrt{73}}{6} \approx -1.5907$.

26. $5m^2 + 5m = 0$

$5m(m + 1) = 0$

$5m = 0$ or $m + 1 = 0$

$m = 0$ or $m = -1$

The solutions are 0 and –1.

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

$$35\left(\frac{3x - 2}{7}\right) = 35\left(\frac{x + 2}{2}\right)$$
$$5(3x - 2) = 7(x + 2)$$
$$15x - 10 = 7x + 14$$
$$8x = 24$$
$$x = 3$$

The solution is $x = 3$.

28. $\frac{x}{3} - 7 = 6 - \frac{3x}{4}$

Multiply both sides by 12, the least common denominator of 3 and 4.

$$12\left(\frac{x}{3} - 7\right) = 12\left(6 - \frac{3x}{4}\right)$$
$$12\left(\frac{x}{3}\right) - (12)(7) = (12)(6) - 12\left(\frac{3x}{4}\right)$$
$$4x - 84 = 72 - 9x$$
$$13x - 84 = 72$$
$$13x = 156$$
$$x = 12$$

The solution is 12.

29. $\frac{4}{x - 3} - \frac{8}{2x + 5} + \frac{3}{x - 3} = 0$

$$\frac{4}{x - 3} + \frac{3}{x - 3} - \frac{8}{2x + 5} = 0$$
$$\frac{7}{x - 3} - \frac{8}{2x + 5} = 0$$

Multiply both sides by $(x - 3)(2x + 5)$. Note that $x \neq 3$ and $x \neq \frac{5}{2}$.

$$(x - 3)(2x + 5)\left(\frac{7}{x - 3} - \frac{8}{2x + 5}\right) = (x - 3)(2x + 5)(0)$$
$$7(2x + 5) - 8(x - 3) = 0$$
$$14x + 35 - 8x + 24 = 0$$
$$6x + 59 = 0$$
$$6x = -59$$
$$x = -\frac{59}{6}$$

Note: It is especially important to check solutions of equations that involve rational expressions. Here, a check shows that $-\frac{59}{6}$ is a solution.

Complete Instructor Answers

Answers to selected writing exercises are provided.

Answers to Prerequisite Skills Diagnostic Test

1. 20% **2.** 51/35 **3.** $x + y = 75$ **4.** $s \geq 4p$ **5.** $-20/3$ (Sec. R.4) **6.** $-11/5$ (Sec. R.4) **7.** $(-2, 5]$ (Sec. R.5) **8.** $x \leq -3$ (Sec. R.5) **9.** $y \geq -17/2$ (Sec. R.5) **10.** $p > 3/2$ (Sec. R.5) **11.** $-y^2 + 4y - 6$ (Sec. R.1) **12.** $x^3 - x^2 + x + 3$ (Sec. R.1) **13.** $a^2 - 4ab + 4b^2$ (Sec. R.1) **14.** $3pq(1 + 2p + 3q)$ (Sec. R.2) **15.** $(3x + 5)(x - 2)$ (Sec. R.2) **16.** $(a - 6)/(a + 2)$ (Sec. R.3) **17.** $(x^2 + 5x - 2)/[x(x - 1)(x + 1)]$ (Sec. R.3) **18.** $(-2 \pm \sqrt{7})/3$ (Sec. R.4) **19.** $(-\infty, -3) \cup [1, \infty)$ (Sec. R.5) **20.** $x^6y/4$ (Sec. R.6) **21.** $2/(p^2q)$ (Sec. R.6) **22.** $(m - k)/(km)$ (Sec. R.6) **23.** $(x^2 + 1)^{-1/2}(3x^2 + x + 5)$ (Sec. R.6) **24.** $4b^2$ (Sec. R.7) **25.** $(4 + \sqrt{10})/3$ (Sec. R.7) **26.** $|y - 5|$ (Sec. R.7)

Chapter R Algebra Reference

Exercises R.1 (page R-5–R-6)

For exercises . . .	1–8	9, 10	11–16	17–24	25–28
Refer to example . . .	2	3	4	5	6

1. $-x^2 + x + 9$ **2.** $-6y^2 + 3y + 10$ **3.** $(3/2)z^2 + (5/6)z + 2$ **4.** $(1/2)t^2 + (1/2)t + 2/3$ **5.** $-16q^2 + 4q + 6$ **6.** $9r^2 - 4r + 19$ **7.** $-0.327x^2 - 2.805x - 1.458$ **8.** $0.8r^2 + 3.6r - 1.5$ **9.** $-18m^3 - 27m^2 + 9m$ **10.** $-12x^4 + 30x^2 + 36x$ **11.** $9t^2 + 9ty - 10y^2$ **12.** $18k^2 - 7kq - q^2$ **13.** $4 - 9x^2$ **14.** $36m^2 - 25$ **15.** $(6/25)y^2 + (11/40)yz + (1/16)z^2$ **16.** $(15/16)r^2 - (7/12)rs - (2/9)s^2$ **17.** $27p^3 - 1$ **18.** $15p^3 + 13p^2 - 10p - 8$ **19.** $8m^3 + 1$ **20.** $12k^4 + 21k^3 - 5k^2 + 3k + 2$ **21.** $3x^2 + xy + 2xz - 2y^2 - 3yz - z^2$ **22.** $2r^2 + 2rs - 5rt - 4s^2 + 8st - 3t^2$ **23.** $x^3 + 6x^2 + 11x + 6$ **24.** $x^3 - 2x^2 - 5x + 6$ **25.** $x^2 + 4x + 4$ **26.** $4a^2 - 16ab + 16b^2$ **27.** $x^3 - 6x^2y + 12xy^2 - 8y^3$ **28.** $27x^3 + 27x^2y + 9xy^2 + y^3$

Exercises R.2 (page R-9)

For exercises . . .	1–4	5–15	16–20	21–32
Refer to example . . .	1	2,3	3, 2nd CAUTION	4

1. $7a^2(a + 2)$ **2.** $3y(y^2 + 8y + 3)$ **3.** $13p^2q(p^2q - 3p + 2q)$ **4.** $10m^2(6m^2 - 12mn + 5n^2)$ **5.** $(m + 2)(m - 7)$ **6.** $(x + 5)(x - 1)$ **7.** $(z + 4)(z + 5)$ **8.** $(b - 7)(b - 1)$ **9.** $(a - 5b)(a - b)$ **10.** $(s - 5t)(s + 7t)$ **11.** $(y - 7z)(y + 3z)$ **12.** $(3x + 7)(x - 1)$ **13.** $(3a + 7)(a + 1)$ **14.** $(5y + 2)(3y - 1)$ **15.** $(7m + 2n)(3m + n)$ **16.** $6(a - 10)(a + 2)$ **17.** $3m(m + 3)(m + 1)$ **18.** $2(2a + 3)(a + 1)$ **19.** $2a^2(4a - b)(3a + 2b)$ **20.** $12x^2(x - y)(2x + 5y)$ **21.** $(x + 8)(x - 8)$ **22.** $(3m + 5)(3m - 5)$ **23.** $10(x + 4)(x - 4)$ **24.** Prime **25.** $(z + 7y)^2$ **26.** $(s - 5t)^2$ **27.** $(3p - 4)^2$ **28.** $(a - 6)(a^2 + 6a + 36)$ **29.** $(3r - 4s)(9r^2 + 12rs + 16s^2)$ **30.** $3(m + 5)(m^2 - 5m + 25)$ **31.** $(x - y)(x + y)(x^2 + y^2)$ **32.** $(2a - 3b)(2a + 3b)(4a^2 + 9b^2)$

Exercises R.3 (page R-12)

For exercises . . .	1–12	13–38
Refer to example . . .	1	2

1. $v/7$ **2.** $5p/2$ **3.** $8/9$ **4.** $2/(t + 2)$ **5.** $x - 2$ **6.** $4(y + 2)$ **7.** $(m - 2)/(m + 3)$ **8.** $(r + 2)/(r + 4)$ **9.** $3(x - 1)/(x - 2)$ **10.** $(z - 3)/(z + 2)$ **11.** $(m^2 + 4)/4$ **12.** $(2y + 1)/(y + 1)$ **13.** $3k/5$ **14.** $25p^2/9$ **15.** $9/(5c)$ **16.** 2 **17.** 1/4 **18.** 3/10 **19.** $2(a + 4)/(a - 3)$ **20.** $2/(r + 2)$ **21.** $(k - 2)/(k + 3)$ **22.** $(m + 6)/(m + 3)$ **23.** $(m - 3)/(2m - 3)$ **24.** $2(2n - 1)/(3n - 5)$ **25.** 1 **26.** $(6 + p)/(2p)$ **27.** $(12 - 15y)/(10y)$ **28.** $137/(30m)$ **29.** $(3m - 2)/[m(m - 1)]$ **30.** $(r - 6)/[r(2r + 3)]$ **31.** $14/[3(a - 1)]$ **32.** $23/[20(k - 2)]$ **33.** $(7x + 1)/[(x - 2)(x + 3)(x + 1)]$ **34.** $(y^2 + 1)/[(y + 3)(y + 1)(y - 1)]$ **35.** $k(k - 13)/[(2k - 1)(k + 2)(k - 3)]$ **36.** $m(3m - 19)/[(3m - 2)(m + 3)(m - 4)]$ **37.** $(4a + 1)/[a(a + 2)]$ **38.** $(5x^2 + 4x - 4)/[x(x - 1)(x + 1)]$

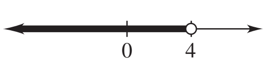
Exercises R.4 (page R-17)

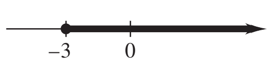
For exercises . . .	1–8	9–26	27–37
Refer to example . . .	2	3–5	6,7

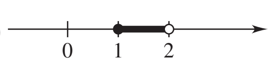
1. -12 **2.** 3/4 **3.** 12 **4.** $-3/8$ **5.** $-7/8$ **6.** $-6/11$ **7.** 4 **8.** $-10/19$ **9.** $-3, -2$ **10.** $-1, 3$ **11.** 7 **12.** $-2, 5/2$ **13.** $-1/4, 2/3$ **14.** 2, 5 **15.** $-3, 3$ **16.** $-4, 1/2$ **17.** 0, 4 **18.** $(5 + \sqrt{13})/6 \approx 1.434$, $(5 - \sqrt{13})/6 \approx 0.232$ **19.** $(2 + \sqrt{10})/2 \approx 2.581$, $(2 - \sqrt{10})/2 \approx -0.581$ **20.** $(-1 + \sqrt{5})/2 \approx 0.618$, $(-1 - \sqrt{5})/2 \approx -1.618$ **21.** $5 + \sqrt{5} \approx 7.236$, $5 - \sqrt{5} \approx 2.764$ **22.** $(4 + \sqrt{6})/5 \approx 1.290$, $(4 - \sqrt{6})/5 \approx 0.310$ **23.** 1, 5/2 **24.** No real number solutions **25.** $(-1 + \sqrt{73})/6 \approx 1.257$, $(-1 - \sqrt{73})/6 \approx -1.591$ **26.** $-1, 0$ **27.** 3 **28.** 12 **29.** $-59/6$ **30.** 6 **31.** 3 **32.** $-5/2$ **33.** 2/3 **34.** 1 **35.** 2 **36.** No solution **37.** No solution

Exercises R.5 (page R-22)

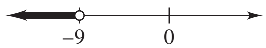
For exercises . . .	1–14	15–26	27–38	39–42	43–54
Refer to example . . .	Figure 1, Example 2	2	3	4	5–7

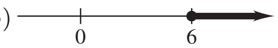
1. $(-\infty, 4)$ 

2. $[-3, \infty)$ 

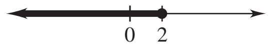
3. $[1, 2)$ 

4. $[-2, 3]$ 

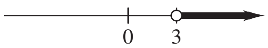
5. $(-\infty, -9)$ 

6. $[6, \infty)$ 

7. $-7 \le x \le -3$ **8.** $4 \le x < 10$ **9.** $x \le -1$ **10.** $x > 3$ **11.** $-2 \le x < 6$ **12.** $0 < x < 8$ **13.** $x \le -4$ or $x \ge 4$

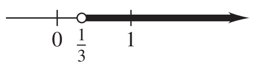
14. $x < 0$ or $x \ge 3$ **15.** $(-\infty, 2]$ 

16. $(-\infty, 1)$ 

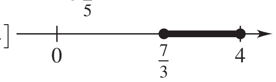
17. $(3, \infty)$ 

18. $(-\infty, 1]$ 

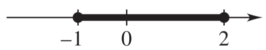
19. $(1/5, \infty)$ 

20. $(1/3, \infty)$ 

21. $(-4, 6)$ 

22. $[7/3, 4]$ 

23. $[-5, 3)$ 

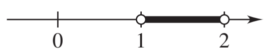
24. $[-1, 2]$ 

25. $[-17/7, \infty)$ 

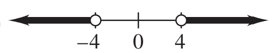
26. $(-\infty, 50/9]$ 

27. $(-5, 3)$ 

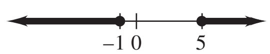
28. $(-\infty, -6] \cup [1, \infty)$ 

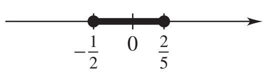
29. $(1, 2)$ 

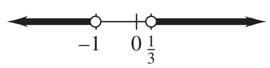
30. $(-\infty, -4) \cup (1/2, \infty)$ 

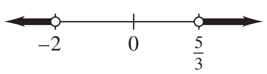
31. $(-\infty, -4) \cup (4, \infty)$ 

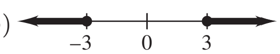
32. $[-3/2, 5]$ 

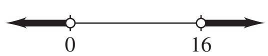
33. $(-\infty, -1] \cup [5, \infty)$ 

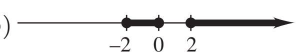
34. $[-1/2, 2/5]$ 

35. $(-\infty, -1) \cup (1/3, \infty)$ 

36. $(-\infty, -2) \cup (5/3, \infty)$ 

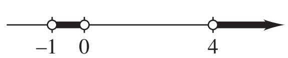
37. $(-\infty, -3] \cup [3, \infty)$ 

38. $(-\infty, 0) \cup (16, \infty)$ 

39. $[-2, 0] \cup [2, \infty)$ 

40. $(-\infty, -4] \cup [-3, 0]$ 

41. $(-\infty, 0) \cup (1, 6)$ 

42. $(-1, 0) \cup (4, \infty)$ 

43. $(-5, 3]$ **44.** $(-\infty, -1) \cup (1, \infty)$ **45.** $(-\infty, -2)$

46. $(-2, 3/2)$ **47.** $[-8, 5)$ **48.** $(-\infty, -3/2) \cup [-13/9, \infty)$ **49.** $[2, 3)$ **50.** $(-\infty, -1)$ **51.** $(-2, 0] \cup (3, \infty)$
52. $(-4, -2) \cup (0, 2)$ **53.** $(1, 3/2]$ **54.** $(-\infty, -2) \cup (-2, 2) \cup [4, \infty)$

Exercises R.6 (page R-26)

For exercises . . .	1–8	9–26	27–36	37–50	51–56
Refer to example . . .	1	2	3,4	5	6

1. $1/64$ **2.** $1/81$ **3.** 1 **4.** 1 **5.** $-1/9$ **6.** $1/9$ **7.** 36 **8.** $27/64$
9. $1/64$ **10.** 8^5 **11.** $1/10^8$ **12.** 7 **13.** x^2 **14.** 1 **15.** $8k^3$ **16.** $1/(3z^7)$ **17.** $x^5/(3y^3)$ **18.** $m^3/5^4$ **19.** a^3b^6
20. $49/(c^6d^4)$ **21.** $(a + b)/(ab)$ **22.** $(1 - ab^2)/b^2$ **23.** $2(m - n)/[mn(m + n^2)]$ **24.** $(3n^2 + 4m)/(mn^2)$
25. $xy/(y - x)$ **26.** $y^4/(xy - 1)^2$ **27.** 11 **28.** 3 **29.** 4 **30.** -25 **31.** $1/2$ **32.** $4/3$ **33.** $1/16$ **34.** $1/5$ **35.** $4/3$
36. $1000/1331$ **37.** 9 **38.** 3 **39.** 64 **40.** 1 **41.** x^4/y^4 **42.** b/a^3 **43.** r **44.** $12^3/y^8$ **45.** $3k^{3/2}/8$ **46.** $1/(2p^2)$
47. $a^{2/3}b^2$ **48.** $y^2/(x^{1/6}z^{5/4})$ **49.** $h^{1/3}t^{1/5}/k^{2/5}$ **50.** m^3p/n **51.** $3x(x^2 + 3x)^2(x^2 - 5)$ **52.** $6x(x^3 + 7)(-2x^3 - 5x + 7)$
53. $5x(x^2 - 1)^{-1/2}(x^2 + 1)$ **54.** $3(6x + 2)^{-1/2}(27x + 5)$ **55.** $(2x + 5)(x^2 - 4)^{-1/2}(4x^2 + 5x - 8)$
56. $(4x^2 + 1)(2x - 1)^{-1/2}(36x^2 - 16x + 1)$

Exercises R.7 (page R-30)

For exercises . . .	1–22	23–26	27–40	41–44
Refer to example . . .	1,2	3	4	5

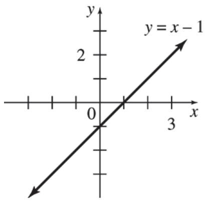
1. 5 **2.** 6 **3.** -5 **4.** $5\sqrt{2}$ **5.** $20\sqrt{5}$ **6.** $4y^2\sqrt{2y}$ **7.** 9 **8.** 8
9. $7\sqrt{2}$ **10.** $9\sqrt{3}$ **11.** $9\sqrt{7}$ **12.** $-2\sqrt{7}$ **13.** $5\sqrt[3]{2}$ **14.** $3\sqrt[3]{5}$ **15.** $xyz^2\sqrt{2x}$ **16.** $4r^3s^4t^6\sqrt{10rs}$ **17.** $4xy^2z^3\sqrt[3]{2y^2}$
18. $x^2yz^2\sqrt[4]{y^3z^3}$ **19.** $ab\sqrt{ab}(b - 2a^2 + b^3)$ **20.** $p^2\sqrt{pq}(pq - q^4 + p^2)$ **21.** $\sqrt[6]{a^5}$ **22.** $b^2\sqrt[4]{b}$ **23.** $|4 - x|$
24. $|3y + 5|$ **25.** Cannot be simplified **26.** Cannot be simplified **27.** $5\sqrt{7}/7$ **28.** $\sqrt{10}/2$ **29.** $-\sqrt{3}/2$ **30.** $\sqrt{2}$
31. $-3(1 + \sqrt{2})$ **32.** $-5(2 + \sqrt{6})/2$ **33.** $3(2 - \sqrt{2})$ **34.** $(5 - \sqrt{10})/3$ **35.** $(\sqrt{r} + \sqrt{3})/(r - 3)$
36. $5(\sqrt{m} + \sqrt{5})/(m - 5)$ **37.** $\sqrt{y} + \sqrt{5}$ **38.** $(z + \sqrt{5z} - \sqrt{z} - \sqrt{5})/(z - 5)$ **39.** $-2x - 2\sqrt{x(x + 1)} - 1$
40. $[p^2 + p + 2\sqrt{p(p^2 - 1)} - 1]/(-p^2 + p + 1)$ **41.** $-1/[2(1 - \sqrt{2})]$ **42.** $1/(3 + \sqrt{3})$
43. $-1/[2x - 2\sqrt{x(x + 1)} + 1]$ **44.** $2/[p + \sqrt{p(p - 2)}]$

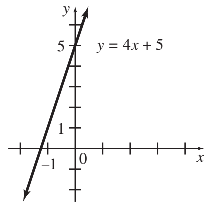
Chapter 1 Linear Functions

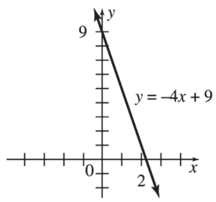
Exercises 1.1 (page 13–17)

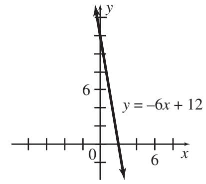
For exercises . . .	5–8	9–12	17,33,34	18,35–38	19–21	22,31	23–28	29,30	32	49–64	65–79
Refer to example . . .	1	3	8	9	4	7	5	2	6	11,12	10,13

W1. −3 **W2.** $y = -2x - 13$
W3. $y = (2/5)x + 19/30$
W4. $y = (2/3)x - 7/3$
1. False **2.** True **3.** False **4.** False **5.** 3/5 **6.** −7/4 **7.** Not defined **8.** 0 **9.** 1 **10.** 3 **11.** 5/9 **12.** −4/7
13. Not defined **14.** 0 **15.** 0 **16.** 0 **17.** 2 **18.** −1/4 **19.** $y = -2x + 5$ **20.** $y = -x + 6$ **21.** $y = -7$ **22.** $x = -8$
23. $y = -(1/3)x + 10/3$ **24.** $y = -x + 7$ **25.** $y = 6x - 7/2$ **26.** $y = (21/32)x + 33/16$ **27.** $x = -8$ **28.** $y = 3$
29. $x + 2y = -6$ **30.** $2x - y = -4$ **31.** $x = -6$ **32.** $y = 7$ **33.** $3x + 2y = 0$ **34.** $2x - y = 9$ **35.** $x - y = 7$
36. $3x + 2y = 6$ **37.** $5x - y = -4$ **38.** $3x + 6y = -2$ **39.** No **40.** **(a)** $k = -1/2$ **(b)** $k = -7/2$ **43.** (a) **44.** (f)
45. −4 **46.** 1/2 **48.** **(a)** $y = -(b/a)x + b$ **(b)** a and b

49.


50.


51.


52.


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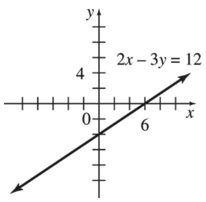

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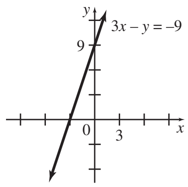

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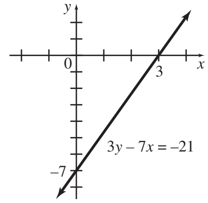

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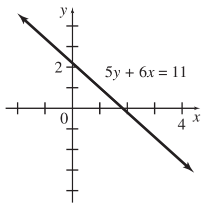

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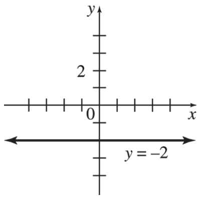

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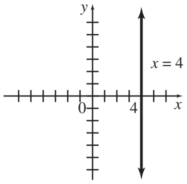

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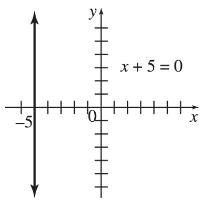

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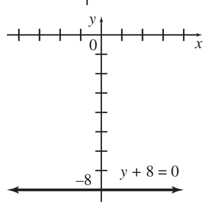

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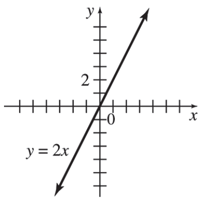

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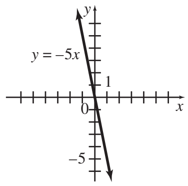

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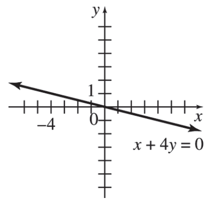

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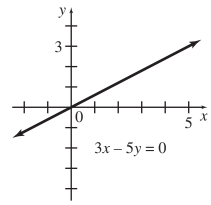
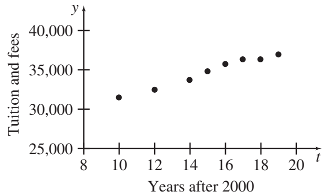
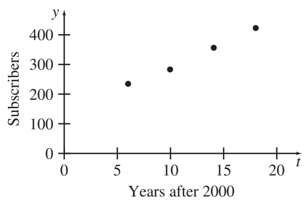


65. **(a)** 12,000; $y = 12{,}000x + 3000$ **(b)** 8 years 1 month **66.** **(a)** 0.9; each additional cupcake costs $0.90
(b) $y = 0.9x + 36$ **(c)** $198

67. **(a)**


Yes **(b)** $y = 598t + 25{,}522$; the slope indicates that the annual cost of tuition and fees at private four-year colleges is increasing by about $598 per year. **(c)** The year 2035 is too far in the future to rely on this equation to predict costs; too many other factors may influence these costs by then.

68. **(a)**


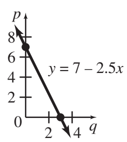
The number of subscribers appears to be increasing at a nearly linear rate.
(b) $y = 15.729t + 138.67$ **(c)** $y = 15.688t + 139.42$
(e) 390.33 million; 390.43 million

69. (a) $y = 4.317t + 87.049$ **(b)** 173.4, which is slightly more than the actual CPI **(c)** It is increasing at a rate of approximately 4.3 per year. **70. (a)** $y = 0.53t - 0.043$ **(b)** About 10.2 yr **71. (a)** $u = 0.85(220 - x) = 187 - 0.85x$, $l = 0.7(220 - x) = 154 - 0.7x$ **(b)** 140 to 170 beats per minute **(c)** 126 to 153 beats per minute **(d)** The women are 16 and 52. Their pulse is 143 beats per minute. **72.** Approximately 4.3 m/sec **73.** About 86 yr **74. (a)** $y = -1.93t + 267$ **(b)** 2026 **75. (a)** $y = 13{,}104.18t - 406{,}022$ **(b)** About 1,166,480 **76. (a)** $y = 0.12t + 25.12$ **(b)** $y = 0.14t + 22.54$ **(c)** Women **(d)** 2038 **(e)** 30.6 **77. (a)** There appears to be a linear relationship. **(b)** $y = 76.9x$ **(c)** About 780 megaparsecs (about 1.5×10^{22} mi) **(d)** About 12.4 billion yr **78. (a)** $T = 0.03t + 15$ **(b)** About 2103 **(c)** $T = 0.02t + 15$; about 2170 **79. (a)** $y_o = 4.625t - 19.25$ **(b)** $y = 4.75t - 41.5$ **(c)** The percent of Americans who had listened to online radio in the previous month increased by 4.625% per year, while the percent of U.S. cellphone users who had ever listened to online radio in a car using a phone increased by 4.75% per year.

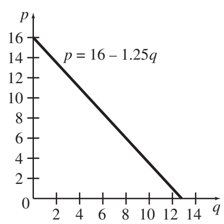
Exercises 1.2 (page 24–27)

For exercises . . .	9–18	23–26	27–30,41,42,49,50	31–36	37–40,43–48	51–53
Refer to example . . .	1	4	5,6	2,3	7	8

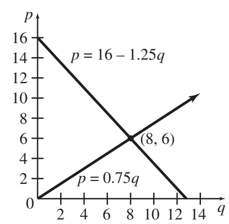
W1. 60 **W2.**



1. True **2.** False **3.** True **4.** True **5.** False **6.** True **7.** True **8.** True **9.** −3 **10.** −13 **11.** 22 **12.** 12 **13.** 0 **14.** 2 **15.** −4 **16.** −9/2 **17.** $7 - 5t$ **18.** $2k^2 - 3$ **23.** If $R(x)$ is the cost of renting a snowboard for x hours, then $R(x) = 2.25x + 10$. **24.** If $C(x)$ is the cost of downloading x songs, then $C(x) = 0.99x + 10$. **25.** If $C(x)$ is the cost of parking a car for x hours, then $C(x) = 0.75x + 2$. **26.** If $R(x)$ is the cost of renting a car for x miles, then $R(x) = 44 + 0.28x$. **27.** $C(x) = 30x + 100$ **28.** $C(x) = 45x + 35$ **29.** $C(x) = 75x + 550$ **30.** $C(x) = 120x + 12{,}500$ **31. (a)** \$16 **(b)** \$11 **(c)** \$6 **(d)** 640 watches **(e)** 480 watches **(f)** 320 watches **(g)**

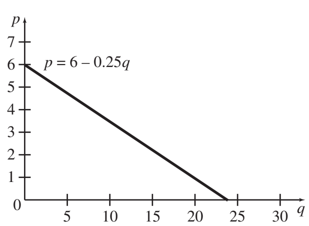


(h) 0 watches **(i)** About 1333 watches **(j)** About 2667 watches **(k)**

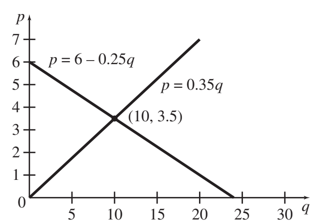


(l) 800 watches, \$6

32. (a) \$6 **(b)** \$5 **(c)** \$3.90 **(d)** 600 quarts **(e)** 1100 quarts **(f)** 1440 quarts **(g)**

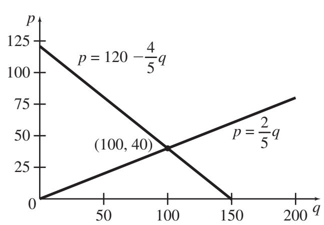


(h) 0 quarts **(i)** 800 quarts **(j)** 1800 quarts **(k)**

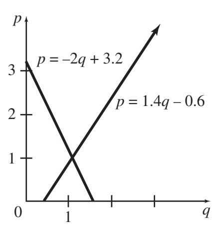


(l) 1000 quarts; \$3.50

33. (a)



(b) 100 tubs, \$40 **34. (a)**



(b) About 1120 lb; about \$0.96

35. $D(q) = 6.9 - 0.4q$ **36.** $D(q) = 9 - 0.35q$ **37. (a)** 2 units **(b)** \$980 **(c)** 52 units **38. (a)** 3 units **(b)** \$3211 **(c)** 13 units **39. (a)** $C(x) = 3.50x + 90$ **(b)** 17 shirts **(c)** 108 shirts **40. (a)** $C(x) = 2.15x + 525$ **(b)** 188 **(c)** 545 books **41. (a)** $C(x) = 0.097x + 1.32$ **(b)** \$1.32 **(c)** \$98.32 **(d)** \$98.417 (or \$98.42) **(e)** 9.7¢ **(f)** 9.7¢, the cost of producing one additional cup of coffee would be 9.7¢. **42. (a)** $C(x) = 500{,}000 + 4.75x$ **(b)** \$500,000 **(c)** \$975,000 **(d)** \$4.75; each additional item costs \$4.75 to produce. **43.** Break-even quantity is 45 units; don't produce; $P(x) = 20x - 900$ **44.** Break-even quantity is about 41 units; produce; $P(x) = 145x - 6000$ **45.** Break-even quantity is −50 units; impossible to make a profit when $C(x) > R(x)$ for all positive x; $P(x) = -10x - 500$ (always a loss) **46.** Break-even quantity is −50 units; impossible to make a profit when $C(x) > R(x)$ for all positive x; $P(x) = -100x - 5000$ (always a loss). **47.** 5 **48.** 26