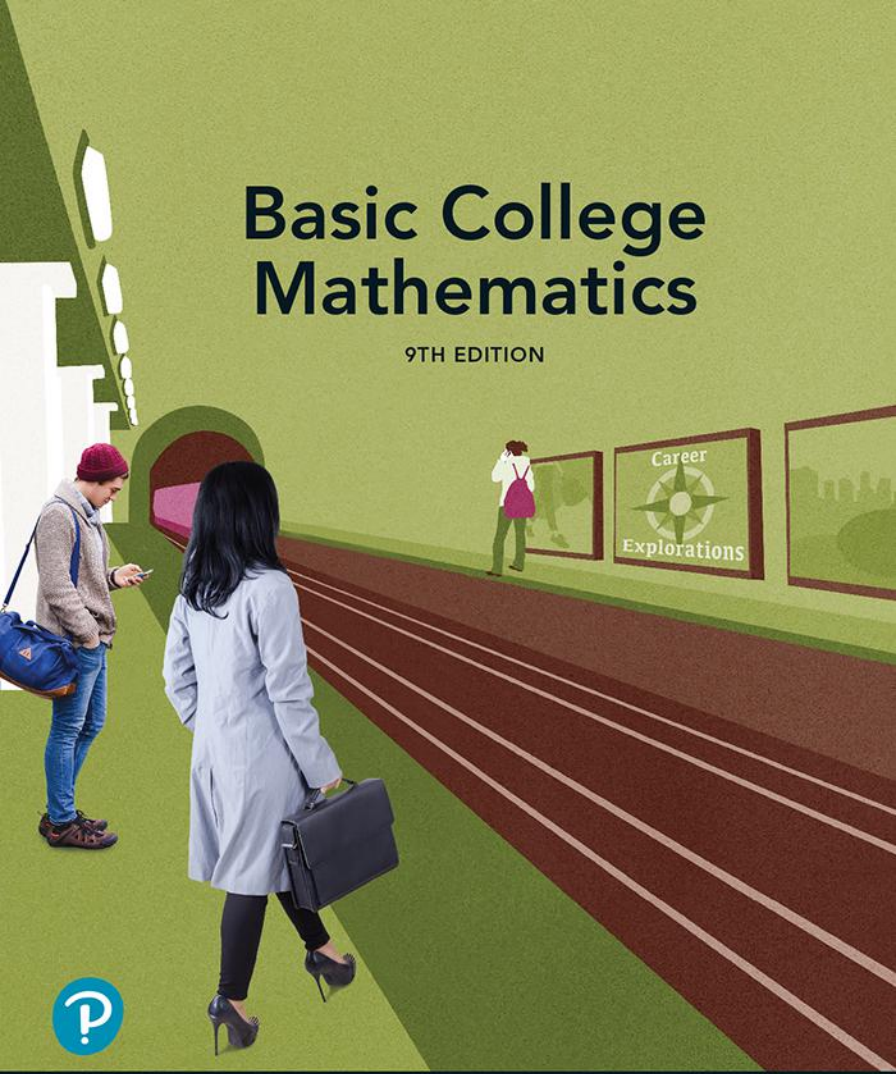
Basic College Mathematics

9TH EDITION



TOBEY SLATER BLAIR CRAWFORD FISCHER

Basic College Mathematics

Ninth Edition

John Tobey
North Shore Community College
Danvers, Massachusetts

Jeffrey Slater
North Shore Community College
Danvers, Massachusetts

Jamie Blair
Orange Coast College
Costa Mesa, California

Jennifer Crawford
Normandale Community College
Bloomington, Minnesota

Anne Fischer
Tulsa Community College
Tulsa, Oklahoma

Library of Congress Cataloging-in-Publication Data

Names: Tobey, John, author. | Slater, Jeffrey author. | Blair, Jamie, author. | Crawford, Jennifer, author. | Fischer, Anne, author.
Title: Basic college mathematics / John Tobey, North Shore Community College, Jeffrey Slater, North Shore Community College, Jamie Blair, Orange Coast Community College, Jennifer Crawford, Normandale Community College, Bloomington, Minnesota, Anne Fischer, Tulsa Community College, Tulsa, Oklahoma.
Description: Ninth edition. | Boston: Pearson Education, [2022] | Includes index.
Identifiers: LCCN 2020022235 | ISBN 9780135840658 (hardcover) | ISBN 9780135840474 (cloth) | ISBN 9780135840634
Subjects: LCSH: Mathematics—Textbooks.
Classification: LCC QA39.3 .T63 2021 | DDC 510—dc23
LC record available at https://lccn.loc.gov/2020022235

Cover Image by Creativa Images/Shutterstock. Photo credits are located on page C-1 and represent an extension of this copyright.

ScoutAutomatedPrintCode

978-0-13-584065-8 (Student edition rental)
978-0-13-584063-4 (Student edition print offer)

This book is dedicated to Nancy Tobey,
A loving wife for fifty-three years,
An outstanding mother of three children,
A joyful and thankful grandmother of seven children,
A dedicated but retired elementary teacher,
My closest friend in all the world.

This edition is dedicated to Joshua and Jordan Fischer,
the greatest joys of my life.

Contents

STEPS TO SUCCESS INDEX: Basic College Mathematics

This page is intentionally left blank

Preface

TO THE INSTRUCTOR

As the authors, we want to let you, the faculty member teaching this course, know that in this book you will find all the resources needed for your students to be successful. We have spent our careers in the classroom talking to students and hearing from them what they need to find success in mathematics. This revision reflects their ideas and suggestions. You can honestly tell students that this book was constructed to really help them.

Developmental mathematics course structures, trends, and dynamics continue to evolve and change, as **course redesign trends** continue to evolve and change, including the introduction of **new pathways-type courses.** Developmental mathematics instructors are increasingly challenged with helping their students **navigate career-oriented math tracks (including non-STEM and STEM pathways)** plus helping students think about **selecting a major** and **workforce readiness.** To help instructors on this front, you'll find an **emphasis on and integration of Career Explorations** throughout the text and MyLab Math course.

Additionally, the program retains its hallmark characteristics that have always made the text so easy to learn and teach from, including its building-block organization. Each section is written to stand on its own, and every homework set is completely self-testing. Exercises are paired and graded and are of varying levels and types to ensure that all skills and concepts are covered. As a result, the text offers students an effective and proven learning program suitable for a variety of course formats—including lecture-based classes; computer-lab based or hybrid classes; discussion-oriented, activity-driven classes; modular and/or self-paced programs; and distance-learning, online programs.

We have visited and listened to teachers across the country and have incorporated a number of suggestions into this edition to help you with the particular learning-delivery system at your school. The following pages describe the key changes in this ninth edition.

KEY ELEMENTS OF THE NINTH EDITION

New Look

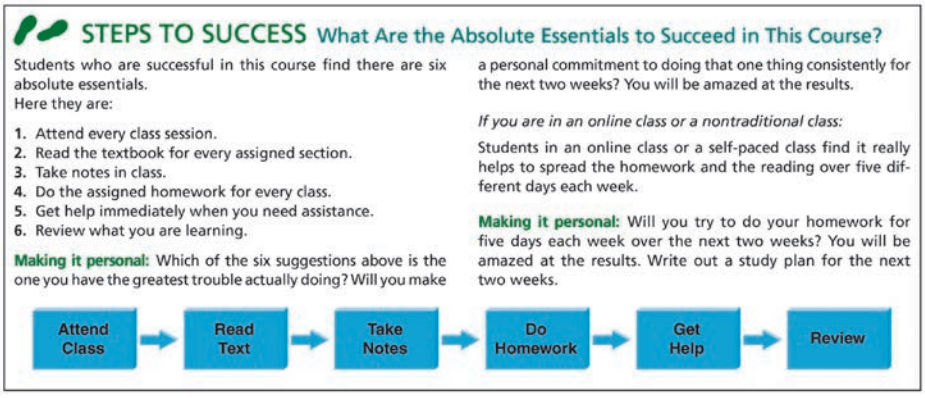
We have updated this title to now have a hard cover for a more durable text experience. We are also asking students to work problems on separate sheets of paper rather than in the text. We encourage the use of MyLab Math, so each student will have their own algorithmically generated version of the question to answer.

New Course Organizer

To learn more about each supporting element of this text and how to use them in all modes of learning (online, hybrid, lecture, self paced) **without losing classroom time**, view a video provided by the author team in the Course Organizer in MyLab Math.

Becoming a Study Skills Coach with Just 2 to 3 Minutes of Class Time

Steps to Success have been integrated throughout the text. You can display these study skills on the classroom screen as students enter and settle in class. In just a few minutes you can encourage and coach your students on the Steps to Success. If you teach online placing the Steps to Success Box at the beginning of your online material will help the student see the importance of these skills.

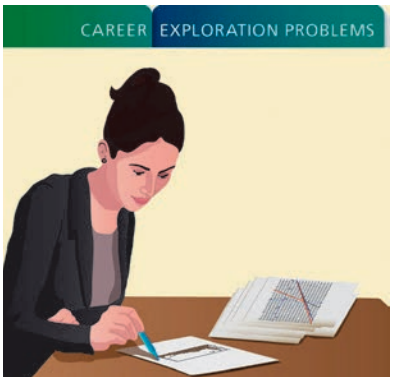


Emphasis in Problem Solving

This successful feature provides an interactive outline to help student organize their approach to problem solving. It is a guide for students to use when faced with a problem that is unfamiliar, to alleviate anxiety, to show them where to begin and assist them in reasoning through a problem. Once filled in, students can refer back to their plan.

Mathematics Blueprint for Problem Solving

Gather the Facts	What Am I Asked to Do?	How Do I Proceed?	Key Points to Remember
The triangle has three sides: $2\frac{1}{4}$ yd, $1\frac{1}{4}$ yd, and $2\frac{3}{4}$ yd.	Find the perimeter.	Add the lengths of the three sides. Then change the answer from yards to feet.	Be sure to change the number of yards to an improper fraction before multiplying by 3 to obtain feet.



Career Explorations Interactions for Students

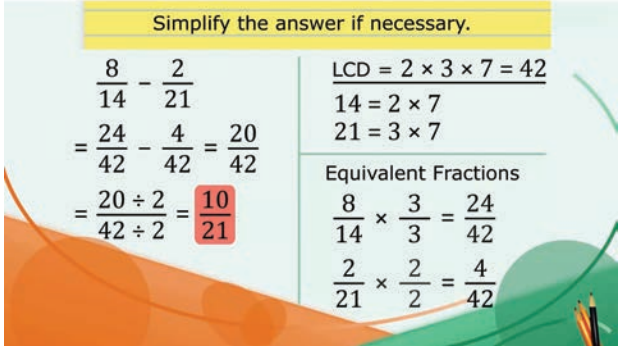
Each chapter begins with a **Career Opportunities** feature that enables students to personally investigate possible future career options while putting the math into context. Students are asked simple, interactive questions prompting them to consider employment opportunities that perhaps they had never thought possible.

Then students are directed to the corresponding **Career Exploration Problems** where they can actually solve problems that help them visualize what work would be like in that career field. This feature opens up possibilities for personal success in future employment.

The Career Exploration Problems are also assignable in MyLab Math, allowing this feature to be seamlessly integrated with the technology. The problems help to foster active learning and better understanding of the math concepts.

Guided Learning Videos

Faculty have asked for specific interactive videos that will clearly show each step of the **key concepts** of each chapter. With this revision, you'll find a series of Guided Learning Videos that lead students from passive learning into active engagement with the material. With the intention of helping students to develop their own notes, students are reminded to pause and write down important definitions and processes. They are also asked throughout the videos to pause **when the pencil icon appears** and try an exercise on their own before continuing. For student ease, icons throughout the eText indicate where the videos are available. The eText is clickable, opening the videos on the spot.



Extensive Video Program

In addition to the Guided Learning Videos with icons throughout the eText, objective-level video clips have also been added to the MyLab Math course with accompanying icons throughout the eText. These video additions expand upon an already complete video lecture series available in MyLab Math. Students and instructors will also find complete Section Lecture Videos, Math Coach Videos, and Chapter Test Prep Videos.

- **The Math Coach** is available within the MyLab Math course, with even more stepped-out, guided Math Coach problems assignable in MyLab Math. Within the text, following each Chapter Test, the **Math Coach** provides students with a personal office-hour experience by walking them through problems step-by-step and pointing out some helpful hints to keep them from making common errors on test problems. For additional help, students can also watch the authors work through these problems on the accompanying Math Coach videos in the MyLab Math course. Instructors can also assign the Math Coach problems in MyLab Math.

- **Use Math to Save Money Animations** are available in the MyLab Math course. The animations expand upon a favorite feature from the text, allowing students to put the math they just learned into context. These newly created animations are set to music and depict real-life scenarios and real-life people using math to cut costs and spend less. To ensure that students watch and understand the animations, there are accompanying Use Math to Save Money homework assignments available in MyLab Math, which are prebuilt for instructor convenience.
- Fifteen percent of the exercises throughout the text have been refreshed.
- Real-world application problems have been updated throughout the text.

Exercises and **Mixed Practice** problems in both the textbook and MyLab Math have been revised so that students have adequate practice on all objectives. All concepts are fully represented, with every Example from the section covered by a group of exercises. The Mixed Practice problems require students to identify the type of problem and the best method to solve it so they have a better understanding of the concepts in the section.

Throughout the text the **Applications** exercises and examples have been updated. These applications relate to everyday life, global issues beyond the borders of the United States, and other academic disciplines. Roughly 25 percent of the applications have been contributed by actual students based on scenarios they have encountered in their home or work lives.

To make sure you and your students are getting the most out of the text *and* the MyLab Math course, see the following MyLab Math feature descriptions.

MyLab Math Resources for

Success

Pearson MyLab

MyLab Math is available to accompany Pearson's market-leading text options, including ***Basic College Mathematics,*** **9th Edition,** 9780135840252.

MyLab™ is the teaching and learning platform that empowers you to reach every student. MyLab Math combines trusted author content—including full eText and assessment with immediate feedback—with digital tools and a flexible platform to personalize the learning experience and improve results for each student.

Student Resources

Each student learns at a different pace. Personalized learning though MyLab Math pinpoints the precise areas where each student needs practice, giving all students the support they need—when and where they need it—to be successful.

New Steps to Success Index Found before the table of contents this index highlights study skills to help students successfully complete the course.

Real-World Application Problems and Examples have been updated throughout the text.

New Assignable MyLab Math Questions bring video content to life for easy concept mastery.

Student Success Module, an interactive module built into the MyLab navigation bar, includes videos, activities, and post-tests for Math-Read Connections, Study Skill, and College Success.

Exercises with Immediate Feedback in MyLab Math reflect the approach and learning style of this text and regenerate algorithmically to give students unlimited opportunity for practice and mastery. Most exercises include learning aids, such as guided solutions and sample problems, and they offer helpful feedback when students enter incorrect answers.

Exercises and Mixed Practice Problems have been revised in the textbook and in MyLab Math, so that students have adequate practice on all objectives. All concepts are fully represented, with every Example from the section covered by a group of exercises. The Mixed Practice problems require students to identify the type of problem and the best method they should use to solve it so students have a better understanding of the concepts in the section.

Skill Builder offers adaptive practice that is designed to increase students' ability to complete their assignments. By monitoring student performance on their homework, Skill Builder adapts to each student's needs and provides just-in-time, in-assignment practice to help them improve their proficiency of key learning objectives.

NEW Personal Inventory Assessments are a collection of online exercises designed to promote self-reflection and engagement in students. These 33 assessments include topics such as a Stress Management Assessment, Diagnosing Poor Performance and Enhancing Motivation, and Time Management Assessment.

With **Learning Catalytics™,** you'll hear from every student when it matters most. You pose a variety of questions that help students recall ideas, apply concepts, and develop critical-thinking skills. Your students respond using their own smartphones, tablets, or laptops.

pearson.com/mylab/math

MyLab Math Resources for

Success

Pearson MyLab

The **Student Solutions Manual** provides worked-out solutions to all odd-numbered section exercises, even and odd exercises in the Quick Review, mid-chapter reviews, chapter reviews, chapter tests, Math Coach, and cumulative reviews.

Instructor Resources

Your course is unique. So whether you'd like to build your own assignments, teach multiple sections, or set prerequisites, MyLab gives you the flexibility to easily create your course to fit your needs.

Enhanced Assignments, created at the section level, are geared to maximize students' performance with just-in-time prerequisite review. They help keep skills fresh with spaced practice of key concepts and provide opportunities to work exercises without learning aids, so students can check their understanding.

Pearson and **ProctorU** have partnered to provide customers with the first seamless, integrated proctoring service within MyLab™. This artificially intelligent proctoring service gives students the flexibility to take MyLab quizzes and tests on their own schedule and at their location of choice, while allowing the institution to maintain academic integrity. This exclusive opportunity is available to both new or existing partners of ProctorU.

Performance Analytics enable instructors to see and analyze student performance across multiple courses. Based on their current course progress, individuals' performance is identified above, at, or below expectations through a variety of graphs and visualizations. Now included with Performance Analytics, **Early Alerts** use predictive analytics to identify struggling students—even if their assignment scores are not a cause for concern. In both Performance Analytics and Early Alerts, instructors can email students individually or by group to provide feedback.

Accessibility Pearson works continuously to ensure our products are as accessible as possible to all students. Currently we work toward achieving WCAG 2.0 AA for our existing products (2.1 AA for future products) and Section 508 standards, as expressed in the Pearson Guidelines for Accessible Educational Web Media.

Instructor's Solution Manual includes detailed step-by-step solutions to the even-numbered section exercises as well as solutions to every exercise in the Classroom Quiz, mid-chapter reviews, chapter reviews, chapter tests, cumulative tests, and practice final.

Instructor's Resource Manual with Tests and Mini Lectures includes a mini lecture for each text section, two short group activities per chapter, three forms of additional practice exercises, two pretests, six tests, and two final exams for every chapter, both free response and multiple choice, as well as two cumulative tests for every even-numbered chapter.

New Course Organizer provides guidance on how to use the many teaching tools and resources. Meet the authors in a video as they describe how you can implement them easily in the classroom.

PowerPoint Lecture Slides are fully editable and include definitions, key concepts, and examples for use in a lecture setting.

TestGen® enables instructors to build, edit, print, and administer tests using a computerized bank of questions developed to cover all the objectives of the text. TestGen is algorithmically based, allowing instructors to create multiple but equivalent versions of the same question or test with the click of a button. Instructors can also modify test bank questions or add new questions.

To learn more about each supporting element of this text, view a video provided by the author team in the the *Course Organizer* in MyLab Math.

pearson.com/mylab/math

Diagnostic Pretest:
Basic College Mathematics

1. _____

2. _____

3. _____

4. _____

5. _____

6. _____

7. _____

8. _____

9. _____

10. _____

11. _____

12. _____

Chapter 1

1. Add. $3846 + 527$

2. Divide. $58\overline{)1508}$

3. Subtract.
$$\begin{array}{r} 12{,}807 \\ -11{,}679 \\ \hline \end{array}$$

4. The highway department used 115 truckloads of sand. Each truck held 8 tons of sand. How many tons of sand were used?

Chapter 2

5. Add. $\frac{3}{7} + \frac{2}{5}$

6. Multiply and simplify. $3\frac{3}{4} \times 2\frac{1}{5}$

7. Subtract. $2\frac{1}{6} - 1\frac{1}{3}$

8. Mike's car traveled 237 miles on $7\frac{9}{10}$ gallons of gas. How many miles per gallon did he achieve?

Chapter 3

9. Multiply.
$$\begin{array}{r} 51.06 \\ \times\ 0.307 \\ \hline \end{array}$$

10. Divide. $0.026\overline{)0.0884}$

11. The copper pipe was 24.375 centimeters long. Paula had to shorten it by cutting off 1.75 centimeters. How long will the copper pipe be when it is shortened?

12. Russ bicycled 20.5 miles on Monday, 5.8 miles on Tuesday, and 14.9 miles on Wednesday. How many miles did he bicycle on those three days?

Chapter 4

Solve each proportion problem. Round to the nearest tenth if necessary.

13. $\frac{3}{7} = \frac{n}{24}$

14. $\frac{0.5}{0.8} = \frac{220}{n}$

15. Wally's Landscape earned $600 for mowing lawns at 25 houses last week. At that rate, how much would he earn for doing 45 houses?

16. Two cities that are actually 300 miles apart appear to be 8 inches apart on the road map. How many miles apart are two cities that appear to be 6 inches apart on the map?

Chapter 5

Round to the nearest tenth if necessary.

17. Change to a percent: $\frac{3}{8}$

18. 138% of 5600 is what number?

19. At Mountainview College, 53% of the students are women. There are 2067 women at the college. How many students are at the college?

20. At a manufacturing plant, it was discovered that 9 out of every 3000 parts made are defective. What percent of the parts are defective?

Chapter 6

21. 15 qt = _____ gal

22. 3 cm = _____ meter

23. 1.56 tons = _____ lb

24. 4900 kg = _____ milligrams

Chapter 7

Round to the nearest hundredth when necessary. Use $\pi \approx 3.14$ *when necessary.*

▲ **25.** Find the area of a triangle with a base of 34 meters and an altitude of 23 meters.

▲ **26.** Find the cost to install carpet in a circular area with a radius of 5 yards at a cost of $35 per square yard.

27. In a right triangle, the longest side is 15 meters and the shortest side is 9 meters. What is the length of the other side of the triangle?

▲ **28.** How many pounds of fertilizer can be placed in a cylindrical tank that is 4 feet tall and has a radius of 5 feet if one cubic foot of fertilizer weighs 70 pounds?

▲ represents geometry-related content.

13. _____

14. _____

15. _____

16. _____

17. _____

18. _____

19. _____

20. _____

21. _____

22. _____

23. _____

24. _____

25. _____

26. _____

27. _____

28. _____

29. _____

30. _____

31. _____

32. _____

33. _____

34. _____

35. _____

36. _____

37. _____

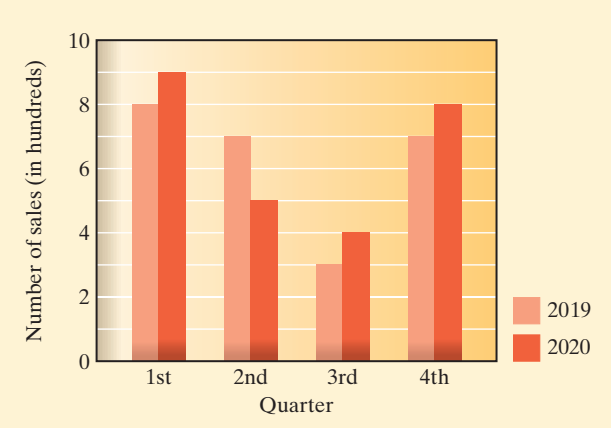
38. _____

39. _____

40. _____

Chapter 8

The following double bar graph indicates the sale of Ram pickups as reported by the district sales managers for a county in a farming area. Use this graph to answer questions 29–32.



29. How many Ram pickups were sold in the second quarter of 2020?

30. How many more Ram pickups were sold in the fourth quarter of 2020 than were sold in the fourth quarter of 2019?

31. In which year were more Ram pickups sold, in 2019 or 2020?

32. What is the *mean* number of Ram pickups sold per quarter in 2019?

Chapter 9

Perform the following operations.

33. $-5 + (-2) + (-8)$

34. $-8 - (-20)$

35. $\left(-\frac{3}{4}\right) \div \left(\frac{5}{6}\right)$

36. $(-3)(2)(-1)(-3)$

Chapter 10

Simplify.

37. $9(x + y) - 3(2x - 5y)$

In questions 38 and 39, solve for x.

38. $3x - 7 = 5x - 19$

39. $2(x - 3) + 4x = -2(3x + 1)$

▲ **40.** A rectangle has a perimeter of 134 meters. The length of the rectangle is 4 meters longer than double the width of the rectangle. What are the length and the width of the rectangle?

CHAPTER 1

Whole Numbers

CAREER OPPORTUNITIES

Truck Driver, Small Business Manager

Have you ever thought about becoming a supervisor or manager in your current job or in another field? Are you interested in owning a business that allows you to travel the nation? A truck driver can own his or her own truck and run it as a small business, where he or she is the only employee. Having mathematical skills is essential for running a successful business on your own.

Learn more about management and transportation industries in the Career Exploration Problems on page **94**.

1.1 Understanding Whole Numbers

Student Learning Objectives

After studying this section, you will be able to:

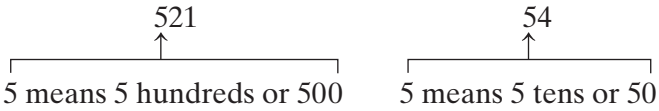
1. Write whole numbers in expanded notation.
2. Write whole numbers in standard notation.
3. Write the word name for a number and write the number for a word name.
4. Read numbers in tables.

1 Writing Whole Numbers in Expanded Notation

To count a number of objects or to answer the question "How many?" we use a set of numbers called **whole numbers.** These whole numbers are as follows.

$$0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, \ldots$$

There is no largest whole number. The three dots . . . indicate that the set of whole numbers goes on indefinitely. Our number system is based on tens and ones and is called the **decimal system** (or the **base 10 system**). The numbers 0, 1, 2, 3, 4, 5, 6, 7, 8, 9 are called **digits.** The position, or placement, of the digits in a number tells the value of the digits. For example, in the number 521, the "5" means 5 hundreds (500). In the number 54, the "5" means 5 tens (50).



For this reason, our number system is called a **place-value system.**

Consider the number 5643. We will use a place-value chart to illustrate the value of each digit in the number 5643.

Place-value Chart

Millions			Thousands			Ones		
					5	6	4	3
Hundred millions	Ten millions	Millions	Hundred thousands	Ten thousands	Thousands	Hundreds	Tens	Ones

The value of the number is 5 thousands, 6 hundreds, 4 tens, 3 ones.

The place-value chart shows the value of each place, from ones on the right to hundred millions on the left. When we write very large numbers, we place a comma after every group of three digits, called a **period,** moving from right to left. This makes the number easier to read. It is usually agreed that a four-digit number does not have a comma but that numbers with five or more digits do. So 32,000 would be written with a comma but 7000 would not.

To show the value of each digit in a number, we sometimes write the number in expanded notation. For example, 56,327 is 5 ten thousands, 6 thousands, 3 hundreds, 2 tens, 7 ones. In **expanded notation,** this is

$$50{,}000 + 6000 + 300 + 20 + 7.$$

Example 1 Write each number in expanded notation.

(a) 2378 **(b)** 538,271 **(c)** 980,340,654

Solution

(a) Sometimes it helps to say the number to yourself.

two thousand three hundred seventy eight

$2378 = 2000 + 300 + 70 + 8$

(b)

Expanded notation

$538{,}271 = 500{,}000 + 30{,}000 + 8000 + 200 + 70 + 1$

(c) When 0 is used as a placeholder, you do not include it in the expanded notation.

Expanded notation

$980{,}340{,}654 = 900{,}000{,}000 + 80{,}000{,}000 + 300{,}000 + 40{,}000 + 600 + 50 + 4$

□

Student Practice 1

Write each number in expanded notation.

(a) 3182 **(b)** 520,890 **(c)** 709,680,059

2 Writing Whole Numbers in Standard Notation

The way that you usually see numbers written is called **standard notation.** 980,340,654 is the standard notation for the number nine hundred eighty million, three hundred forty thousand, six hundred fifty-four.

Example 2 Write each number in standard notation.

(a) $500 + 30 + 8$ **(b)** $300{,}000 + 7000 + 40 + 7$

Solution

(a) 538

(b) Be careful to keep track of the place value of each digit. You may need to use 0 as a placeholder.

3 hundred thousand

$300{,}000 + 7000 + 40 + 7 = 307{,}047$

7 thousand

We needed to use 0 in the ten thousands place and in the hundreds place.

□

Student Practice 2

Write each number in standard notation.

(a) $400 + 90 + 2$ **(b)** $80{,}000 + 400 + 20 + 7$

Example 3 Last year the population of Central City was 1,509,637. In the number 1,509,637

(a) How many ten thousands are there? **(b)** How many tens are there?

(c) What is the value of the digit 5? **(d)** In what place is the digit 6?

Solution A place-value chart will help you identify the value of each place.

(a) Look at the digit in the ten thousands place. There are 0 ten thousands.

(b) Look at the digit in the tens place. There are 3 tens.

(c) The digit 5 is in the hundred thousands place. The value of the digit is 5 hundred thousand or 500,000.

(d) The digit 6 is in the hundreds place. □

Student Practice 3

The campus library has 904,759 books.

(a) What digit tells the number of hundreds?

(b) What digit tells the number of hundred thousands?

(c) What is the value of the digit 4?

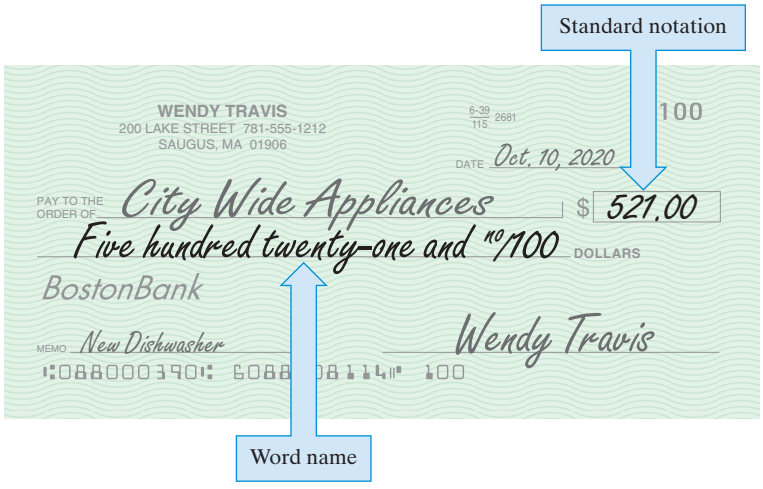
(d) What is the value of the digit 9? Why does this question have two answers?

3 Writing Word Names for Numbers and Numbers for Word Names

A number has the same *value* no matter how we write it. For example, "a million dollars" means the same as "$1,000,000." In fact, any number in our number system can be written in several ways or forms:

- Standard notation 521
- Expanded notation 500 + 20 + 1
- Word name five hundred twenty-one

You may want to write a number in any of these ways. To write a check, you need to use both standard notation and words.



To write a word name, start from the left. Name the number in each period, followed by the name of the period, and a comma. The last period name, "ones," is not used.

Example 4 Write the word name for 364,128,957.

Solution

Place-value Chart

Billions			Millions			Thousands			Ones		
			3	6	4	1	2	8	9	5	7
Hundreds	Tens	Ones	Hundreds	Tens	Ones	Hundreds	Tens	Ones	Hundreds	Tens	Ones

We want to write the word name for 364, 128, 957.

three hundred sixty-four million,

one hundred twenty-eight thousand,

nine hundred fifty-seven

The answer is three hundred sixty-four million, one hundred twenty-eight thousand, nine hundred fifty-seven. □

Student Practice 4

Write the word name for 267,358,981.

Example 5 Write the word name for each number.

(a) 1695 **(b)** 200,470 **(c)** 7,003,038

Solution Look at a place-value chart if you need help identifying the place for each digit.

(a) To help us, we will put in the optional comma: 1,695.

1, 695

one thousand,

six hundred ninety-five

The word name is one thousand, six hundred ninety-five.

(b)

200, 470

two hundred thousand,

four hundred seventy

The word name is two hundred thousand, four hundred seventy.

(c)

7, 003, 038

seven million,

three thousand,

thirty-eight

The word name is seven million, three thousand, thirty-eight. □

Continued on next page

Student Practice 5

Write the word name for each number.

(a) 2736 **(b)** 980,306 **(c)** 12,000,021

CAUTION: DO NOT USE THE WORD AND FOR WHOLE NUMBERS. Many people use the word *and* when giving the word name for a whole number. For example, you might hear someone say the number 34,507 as "thirty-four thousand, five hundred *and* seven." However, this is not technically correct. In mathematics we do NOT use the word *and* when writing word names for whole numbers. In Chapter 3 we will use the word *and* to represent the decimal point. For example, 59.76 will have the word name "fifty-nine *and* seventy-six hundredths."

Very large numbers are used to measure quantities in some disciplines, such as distance in astronomy and the national debt in macroeconomics. We can extend the place-value chart to include these large numbers.

The national debt in the United States as of March 25, 2020, was \$23,542,522,737,423. This number is indicated in the following placevalue chart.

Place-value Chart

Trillions			Billions			Millions			Thousands			Ones		
	2	3	5	4	2	5	2	2	7	3	7	4	2	3

Example 6 Write the word name for the national debt in the United States as of March 25, 2020, in the amount of \$23,542,522,737,423.

Solution The national debt on March 25, 2020, was twenty-three trillion, five hundred forty-two billion, five hundred twenty-two million, seven hundred thirty-seven thousand, four hundred twenty-three. □

Student Practice 6

As of January 1, 2020, the estimated population of the world was 7,714,576,923. Write the word name for this world population.

Occasionally you may want to write a word name as a number.

Example 7 Write each number in standard notation.

(a) twenty-six thousand, eight hundred sixty-four

(b) two billion, three hundred eighty-six million, five hundred forty-seven thousand, one hundred ninety

Solution

(a) twenty-six thousand, eight hundred sixty-four

$26,864$ Thus we have 26,864.

(b) two billion, three hundred eighty-six million, five hundred forty-seven thousand, one hundred ninety

$2,386,547,190$ Thus we have 2,386,547,190. □

Student Practice 7

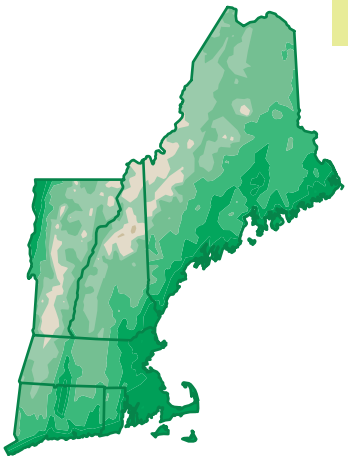
Write in standard notation.

(a) eight hundred three

(b) thirty thousand, two hundred twenty-nine

4 Reading Numbers in Tables

Sometimes numbers found in charts and tables are abbreviated. Look at the chart below from the U.S. Bureau of the Census. Notice that the second line tells us the numbers represent thousands. To understand what these numbers mean, think "thousands." Since the number 23 appears across from 1740 for New Hampshire, the 23 represents 23 thousand. 23 thousand is 23,000. Note that census figures for some colonies are not available for certain years.



Estimated Population of the American Colonies from 1650 to 1780 (in thousands)

	Maine	New Hampshire	Vermont	Plymouth & Massachusetts	Rhode Island	Connecticut
1650	1	1	★	16	1	4
1670	★	2	★	35	2	13
1690	★	4	★	57	4	22
1700	★	5	★	56	6	26
1720	★	9	★	91	12	59
1740	★	23	★	152	25	90
1750	★	28	★	188	33	111
1770	31	62	10	235	58	184
1780	49	88	48	269	53	207

Example 8 Refer to the chart on the previous page to answer the following questions. Write each number in standard notation.

(a) What was the estimated population of Maine in 1780?

(b) What was the estimated population of Plymouth and Massachusetts in 1720?

(c) What was the estimated population of Rhode Island in 1700?

Solution

(a) To read the chart, first look for Maine along the top. Read down to the row for 1780. The number is 49. In this chart 49 means 49 thousands.

$$49 \text{ thousands} \Rightarrow 49{,}000$$

(b) Read the column of the chart for Plymouth and Massachusetts. The number for Plymouth and Massachusetts in the row for 1720 is 91. This means 91 thousands. We will write this as 91,000.

(c) Read the column of the chart for Rhode Island. The number for Rhode Island in the row for 1700 is 6. This means 6 thousands. We will write this as 6000.

To Think About: *Interpreting Data in a Table* Why do you think Plymouth and Massachusetts had the largest population for the years shown in the table? □

Student Practice 8

Refer to the chart on the previous page to answer the following questions. Write each number in standard notation.

(a) What was the estimated population of Connecticut in 1670?

(b) What was the estimated population of New Hampshire in 1780?

(c) What was the estimated population of Vermont in 1770?

STEPS TO SUCCESS Be Involved.

If you are in a traditional class:

Don't just sit on the sidelines of the class and watch. Take part in the classroom discussion. People learn mathematics best through active participation. Whenever you are not clear about something, ask a question. Usually your questions will be helpful to other students in the room. When the teacher asks for suggestions, be sure to contribute your own ideas. Sit near the front where you can see and hear well. This will help you to focus on the material being covered

Making it personal: Which of the suggestions above is the one you most need to follow? On a separate sheet of paper, write down what you need to do to improve in this area.

If you are in an online class or a nontraditional class:

Be sure to e-mail the teacher. Talk to the tutor on duty. Ask questions. Think about concepts. Make your mind interact with the textbook. Be mentally involved. This active mental interaction is the key to your success.

Making it personal: Which of the suggestions is the one you most need to follow? On a separate sheet of paper, write down what you need to do to improve in this area.

1.1 Exercises MyLab™ Math

Write each number in expanded notation.

1. 8653

2. 7834

3. 108,276

4. 304,726

5. 23,761,345

6. 59,236,781

7. 103,260,768

8. 820,310,574

Write each number in standard notation.

9. 600 + 70 + 1

10. 500 + 90 + 6

11. 9000 + 800 + 60 + 3

12. 7000 + 600 + 50 + 2

13. 40,000 + 800 + 80 + 5

14. 60,000 + 7000 + 200 + 4

15. 700,000 + 60,000 + 2000 + 30

16. 300,000 + 40,000 + 800

Verbal and Writing Skills, Exercises 17–20

17. In the number 437,521

(a) What digit tells the number of thousands?

(b) What is the value of the digit 3?

18. In the number 805,712

(a) What digit tells the number of ten thousands?

(b) What is the value of the digit 8?

19. In the number 1,214,847

(a) What digit tells the number of hundred thousands?

(b) What is the value of the digit?

20. In the number 6,789,345

(a) What digit tells the number of thousands?

(b) What is the value of the digit?

Write the word name for each number.

21. 142

22. 376

23. 9304

24. 7606

25. 36,118

26. 55,742

27. 105,261

28. 370,258

29. 14,203,326

30. 68,089,213

31. 4,302,156,200

32. 7,436,210,400

Write each number in standard notation.

33. one thousand, five hundred sixty-one

34. three thousand, one hundred eighty-nine

35. thirty-three thousand, eight hundred nine

36. two hundred three thousand, three hundred seventy-four

37. one hundred million, seventy-nine thousand, eight hundred twenty-six

38. four hundred fifty million, three hundred thousand, two hundred forty-nine

Applications *When writing a check, a person must write the word name for the dollar amount of the check.*

39. ***Personal Finance*** Alex bought new equipment for his laboratory for $1965. What word name should he write on the check?

40. ***Personal Finance*** Alex later bought a new desktop computer for $1749. What word name should he write on the check?

In exercises 41–44, use the following chart prepared with data from the U.S. Bureau of the Census. Notice that the second line tells us that the numbers represent millions. These values are only approximate values representing numbers written to the nearest million. They are not exact census figures.

Estimated Population of Four States from 1910 to 2020 (in millions)

	California	Florida	Illinois	New York
1910	2	1	5	9
1920	3	1	6	10
1930	6	1	8	13
1940	7	2	8	13
1950	11	3	9	15
1960	16	5	10	17
1970	20	7	11	18
1980	24	10	11	18
1990	30	13	11	18
2000	33	15	12	18
2010	38	20	13	19
2020*	42	23	13	20

*estimated

Source: U.S. Bureau of the Census

41. ***Historical Analysis*** What was the estimated population of New York in 1910?

42. ***Historical Analysis*** What was the estimated population of Florida in 1970?

43. ***Historical Analysis*** What is the estimated population of California in 2020?

44. ***Historical Analysis*** What was the estimated population of Illinois in 1940?

In exercises 45–48, use the following chart:

Top Five Airports in the U.S. and Number of Passengers Departing per Year (in thousands)

Cities	2014	2015	2016	2017	2018
Atlanta	48,233	49,320	50,480	50,243	51,849
Los Angeles	34,283	36,437	39,606	41,201	42,708
Chicago O'Hare	33,574	36,246	37,497	38,577	39,896
Dallas/Ft. Worth	30,742	31,569	31,260	31,794	32,781
Denver	25,978	26,251	28,242	29,786	31,346

Source: Bureau of Transportation Statistics

45. ***Airline Travel*** How many passengers flew from Chicago O'Hare in 2016?

46. ***Airline Travel*** How many passengers flew from Denver in 2017?

47. ***Airline Travel*** How many passengers flew from Dallas/Ft. Worth in 2015?

48. ***Airline Travel*** How many passengers flew from Los Angeles in 2014?

49. ***Physics*** The speed of light is approximately 29,979,250,000 centimeters per second.

(a) What digit tells the number of ten thousands?

(b) What digit tells the number of ten billions?

▲ **50.** ***Earth Science*** The circumference of Earth at the equator is 131,480,184 feet.

(a) What digit tells the number of ten millions?

(b) What digit tells the number of hundred thousands?

51. ***Blood Vessels*** There are about 316,820,000 feet of blood vessels in an adult human body.

(a) What digit tells the number of ten thousands?

(b) What digit tells the number of ten millions?

52. ***U.S. Currency*** In 2018, the value of all $100 bills in circulation in the United States was $1,154,872,639,700.

(a) What digit tells the number of hundred thousands?

(b) What digit tells the number of ten millions?

53. Write in standard notation: six hundred thirteen trillion, one billion, thirty-three million, two hundred eight thousand, three.

54. Write in standard notation: eight hundred thirty-six billion, forty-seven million, nine hundred twenty-seven thousand, three hundred sixteen.

To Think About

55. Write the word name for 3,682,968,009,931,960,747. (*Hint:* The digit 1 followed by 18 zeros represents the number *1 quintillion.* 1 followed by 15 zeros represents the number *1 quadrillion*.)

56. The number 50,000,000,000,000,000,000 is represented on some scientific calculators as 5 E 19. We will cover this in more detail in a later chapter. However, for the present we can see that this is a convenient notation that allows us to record very large whole numbers. Note that this number (50 quintillion) is a 5 followed by 19 zeros. Write in standard notation the number that would be represented on a calculator as 6 E 22.

57. Think about the discussion in exercise 56. If the number 4 E 20 represented on a scientific calculator was divided by 2, what number would be the result? Write your answer in standard notation.

58. Consider all the whole numbers between 200 and 800 that contain the digit 6. How many such numbers are there?

Quick Quiz 1.1

1. Write in expanded notation. 73,952

2. Write the word name. 8,932,475

3. Write in standard notation.
Nine hundred sixty-four thousand, two hundred fifty-seven

4. **Concept Check** Explain why the zeros are needed when writing the following number in standard notation: three hundred sixty-eight million, five hundred twenty-two.

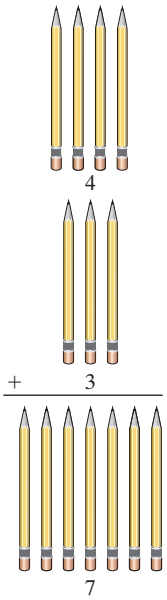
▲ represents geometry-related content.

1.2 Adding Whole Numbers

Student Learning Objectives

After studying this section, you will be able to:

1. Master basic addition facts.
2. Add several single-digit numbers.
3. Add several-digit numbers when carrying is not needed.
4. Add several-digit numbers when carrying is needed. GUIDED LEARNING VIDEO
5. Review the properties of addition.
6. Apply addition to real-life situations.



1 Mastering Basic Addition Facts

We see the addition process time and time again. Carpenters add to find the amount of lumber they need for a job. Auto mechanics add to make sure they have enough parts in the inventory. Bank tellers add to get cash totals.

What is addition? We do addition when we put sets of objects together.

5 objects + 7 objects = 12 objects

$$5 + 7 = 12$$

Usually when we add numbers, we put one number under the other in a column. The numbers being added are called **addends.** The result is called the **sum.**

Suppose that we have four pencils in the car and we bring three more pencils from home. How many pencils do we have with us now? We add 4 and 3 to obtain a value of 7. In this case, the numbers 4 and 3 are the addends and the answer 7 is the sum.

$$\begin{array}{rl} 4 & \text{addend} \\ +\ 3 & \text{addend} \\ \hline 7 & \text{sum} \end{array}$$

Think about what we do when we add 0 to another number. We are not making a change, so whenever we add zero to another number, that number will be the sum. Because this is always true, this is called a *property.* Because the sum is identical to the number that is added to zero, this is called the **identity property of zero.**

Example 1 Add.

(a) $8 + 5$ **(b)** $3 + 7$ **(c)** $9 + 0$

Solution

(a) $\begin{array}{r} 8 \\ +\ 5 \\ \hline 13 \end{array}$ **(b)** $\begin{array}{r} 3 \\ +\ 7 \\ \hline 10 \end{array}$ **(c)** $\begin{array}{r} 9 \\ +\ 0 \\ \hline 9 \end{array}$ ← *Note:* When we add zero to any other number, that number is the sum. □

Student Practice 1

Add.

(a) $\begin{array}{r} 6 \\ +\ 5 \\ \hline \end{array}$ **(b)** $\begin{array}{r} 9 \\ +\ 4 \\ \hline \end{array}$ **(c)** $\begin{array}{r} 3 \\ +\ 0 \\ \hline \end{array}$

The following table shows the basic addition facts. You should know these facts. If any of the answers don't come to you quickly, now is the time to learn them. To check your knowledge try Exercises 1.2, exercises 3 and 4.

Basic Addition Facts

+	0	1	2	3	4	5	6	7	8	9
0	0	1	2	3	4	5	6	7	8	9
1	1	2	3	4	5	6	7	8	9	10
2	2	3	4	5	6	7	8	9	10	11
3	3	4	5	6	7	8	9	10	11	12
4	4	5	6	7	8	9	10	11	12	13
5	5	6	7	8	9	10	11	12	13	14
6	6	7	8	9	10	11	12	13	14	15
7	7	8	9	10	11	12	13	14	15	16
8	8	9	10	11	12	13	14	15	16	17
9	9	10	11	12	13	14	15	16	17	18

To use the table to find the sum $4 + 7$, read across the top of the table to the 4 column, and then read down the left to the 7 row. The box where the 4 and 7 meet is 11, which means that $4 + 7 = 11$. Now read across the top of the table to the 7 column and down the left to the 4 row. The box where these numbers meet is also 11. We can see that the order in which we add the numbers does not change the sum. $4 + 7 = 11$, and $7 + 4 = 11$. We call this the **commutative property of addition.**

This property does not hold true for everything in our lives. When you put on your socks and then your shoes, the result is not the same as if you put on your shoes first and then your socks! Can you think of any other examples where changing the order in which you add things would change the result?

2 Adding Several Single-Digit Numbers

If more than two numbers are to be added, we usually add from the first number to the next number and mentally note the sum. Then we add that sum to the next number, and so on.

Example 2 Add. $3 + 4 + 8 + 2 + 5$

Solution We rewrite the addition problem in a column format.

$$\begin{array}{r} 3 \\ 4 \\ 8 \\ 2 \\ +\ 5 \\ \hline 22 \end{array}$$

$3 + 4 = 7$

Mentally, we do these steps.

$7 + 8 = 15$

$15 + 2 = 17$

$17 + 5 = 22$

Student Practice 2

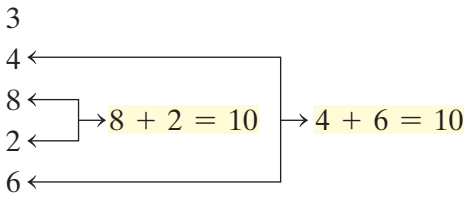
Add. $7 + 6 + 5 + 8 + 2$

Because the order in which we add numbers doesn't matter, we can choose to add from the top down, from the bottom up, or in any other way. One shortcut is to add first any numbers that will give a sum of 10, or 20, or 30, and so on.

Example 3 Add.

$$\begin{array}{r} 3 \\ 4 \\ 8 \\ 2 \\ +\ 6 \\ \hline \end{array}$$

Solution We mentally group the numbers into tens.



The sum is 10 + 10 + 3 or 23. □

Student Practice 3

Add. 1 + 7 + 2 + 9 + 3

3 Adding Several-Digit Numbers When Carrying Is Not Needed

Of course, many numbers that we need to add have more than one digit. In such cases, we must be careful to first add the digits in the ones column, then the digits in the tens column, then those in the hundreds column, and so on. Notice that we move from *right to left*.

Example 4 Add. 4304 + 5163

Solution

$$\begin{array}{r} 4\ 3\ 0\ 4 \\ +\ 5\ 1\ 6\ 3 \\ \hline 9\ 4\ 6\ 7 \end{array}$$

sum of 4 ones + 3 ones = 7 ones

sum of 0 tens + 6 tens = 6 tens

sum of 3 hundreds + 1 hundred = 4 hundreds

sum of 4 thousands + 5 thousands = 9 thousands □

Student Practice 4

Add.

$$\begin{array}{r} 8246 \\ +\ 1702 \\ \hline \end{array}$$

4 Adding Several-Digit Numbers When Carrying Is Needed

GUIDED LEARNING VIDEO

When you add several whole numbers, often the sum in a column is greater than 9. However, we can only use *one* digit in any one place. What do we do with a two-digit sum? Look at the following example.

Example 5 Add. 45 + 37

Solution

$$\begin{array}{r} {\scriptstyle 1} \\ 4\ 5 \\ +\ 3\ 7 \\ \hline 2 \end{array}$$

5 ones and 7 ones = 12.
We rename 12 in expanded notation: 1 ten + 2 ones.
We place the 2 ones in the ones column.
We carry the 1 ten over to the tens column.

Note: Placing the 1 in the next column is often called "carrying the one."

$$\begin{array}{r} {\scriptstyle 1} \\ 4\ 5 \\ +\ 3\ 7 \\ \hline 8\ 2 \end{array}$$

Now we can add the digits in the tens column.

Thus, 45 + 37 = 82. □

Student Practice 5

Add.

$$\begin{array}{r} 56 \\ +\ 36 \\ \hline \end{array}$$

Often you must use carrying several times by bringing the left digit into the next column to the left.

Example 6 Add. 257 + 688 + 94

Solution

Thousands Column
Hundreds Column
Tens Column
Ones Column

$$\begin{array}{r} {\scriptstyle 2}\ {\scriptstyle 1} \\ 2\ 5\ 7 \\ 6\ 8\ 8 \\ +\ \ 9\ 4 \\ \hline 1\ 0\ 3\ 9 \end{array}$$

In the ones column we add 7 + 8 + 4 = 19. Because 19 is 1 ten and 9 ones, we place 9 in the ones column and carry 1 to the top of the tens column.

In the tens column we add 1 + 5 + 8 + 9 = 23. Because 23 tens is 2 hundreds and 3 tens, we place the 3 in the tens column and carry 2 to the top of the hundreds column.

In the hundreds column we add 2 + 2 + 6 = 10 hundreds. Because 10 hundreds is 1 thousand and 0 hundreds, we place the 0 in the hundreds column and place the 1 in the thousands column.

□

Student Practice 6

Add. 789 + 63 + 297

We can add numbers in more than one way. To add $5 + 3 + 7$ we can first add the 5 and 3. We do this by using parentheses to show the first operation to be done. This shows us that $5 + 3$ is to be grouped together.

$$\begin{aligned} 5 + 3 + 7 &= (5 + 3) + 7 = 15 \\ &= \quad 8 \quad + 7 = 15 \end{aligned}$$

We could add the 3 and 7 first. We use parentheses to show that we group $3 + 7$ together and that we will add these two numbers first.

$$\begin{aligned} 5 + 3 + 7 &= 5 + (3 + 7) = 15 \\ &= 5 + \quad 10 \quad = 15 \end{aligned}$$

The way we group numbers to be added does not change the sum. This property is called the **associative property of addition.**

5 Reviewing the Properties of Addition

Look again at the three properties of addition we have discussed in this section.

1. **Identity Property of Zero** When zero is added to a number, the sum is that number.	$8 + 0 = 8$ $0 + 5 = 5$
2. **Commutative Property of Addition** Two numbers can be added in either order with the same result.	$5 + 12 = 12 + 5$ $17 = 17$
3. **Associative Property of Addition** When we add three numbers, we can group them in any way.	$(8 + 2) + 6 = 8 + (2 + 6)$ $10 + 6 = 8 + 8$ $16 = 16$

Because of the commutative and associative properties of addition, we can check our addition by adding the numbers in the opposite order.

Example 7

(a) Add the numbers. $39 + 7284 + 3132$

(b) Check by reversing the order of addition.

Solution **(a)**

$$\begin{array}{r} {\scriptstyle 1\,1}\\ 39\\ 7284\\ +\ 3132\\ \hline 10{,}455 \end{array}$$

Addition

(b)

$$\begin{array}{r} {\scriptstyle 1\,1}\\ 3132\\ 7284\\ +\ \ 39\\ \hline 10{,}455 \end{array}$$

Check by reversing the order.

The sum is the same in each case. □

Student Practice 7

(a) Add.

$$\begin{array}{r} 127\\ 9876\\ +\ \ 342 \end{array}$$

(b) Check by reversing the order.

$$\begin{array}{r} 342\\ 9876\\ +\ \ 127 \end{array}$$

6 Applying Addition to Real-Life Situations

We use addition in all kinds of situations. There are several key words in word problems that imply addition. For example, it may be stated that there are 12 math books, 9 chemistry books, and 8 biology books on a shelf. To find the *total* number of books implies that we add the numbers 12 + 9 + 8. Other key words are *how much, how many,* and *all.*

Sometimes a problem will have more information than you will need to answer the question. If you have too much information, you will need to separate out the facts that are not important in order to solve the problem. The following three steps are involved in the problem-solving process.

Step 1. Understand the problem.

Step 2. Calculate and state the answer.

Step 3. Check.

We may not write all of these steps down, but they are the steps we use to solve all problems.

Example 8 The bookkeeper for Smithville Trucking was examining the following data for the company checking account.

Monday:	$23,416 was deposited and $17,389 was debited.
Tuesday:	$44,823 was deposited and $34,089 was debited.
Wednesday:	$16,213 was deposited and $20,057 was debited.

What was the total of all deposits during this period?

Solution

Step 1. ***Understand the problem.***

Total implies that we will use addition. Since we don't need to know about the debits to answer this question, we use only the *deposit* amounts.

Step 2. ***Calculate and state the answer.***

Monday:	$23,416 was deposited.	$\overset{1\,1}{2}3,\overset{1}{4}16$
Tuesday:	$44,823 was deposited.	44,823
Wednesday:	$16,213 was deposited.	+ 16,213
		84,452

A total of $84,452 was deposited on those three days.

Step 3. ***Check.***

You may add the numbers in reverse order to check. We leave the check up to you. □

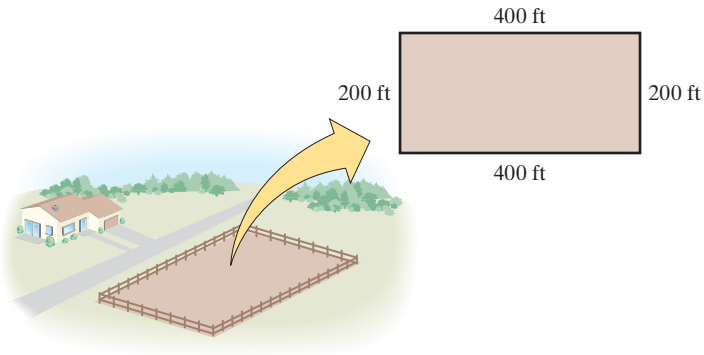
Student Practice 8

North Pacific University has 23,413 men and 18,316 women. South County University has 19,316 men and 24,789 women. East County University has 20,078 men and 22,965 women. What is the total enrollment of women at the three universities?

▲ **Example 9** Mr. Ortiz has a rectangular field whose length is 400 feet and whose width is 200 feet. What is the total number of feet of fence that would be required to fence in the field?

Solution

1. ***Understand the problem.*** To help us to get a picture of what the field looks like, we will draw a diagram.



Note that ft is the abbreviation for feet. ft means feet.

2. ***Calculate and state the answer.*** Since the fence will be along each side of the field, we add the lengths all around the field.

$$\begin{array}{r} 200 \\ 400 \\ 200 \\ +\ 400 \\ \hline 1200 \end{array}$$

The amount of fence that would be required is 1200 feet.

3. ***Check.*** Regroup the addends and add.

$$\begin{array}{r} 200 \\ 200 \\ 400 \\ +\ 400 \\ \hline 1200 \end{array} \checkmark$$

□

▲ **Student Practice 9**

In Vermont, Gretchen fenced the rectangular field on which her sheep graze. The length of the field is 2000 feet and the width of the field is 1000 feet. What is the perimeter of the field? (*Hint:* The "distance around" an object [such as a field] is called the *perimeter.*)

STEPS TO SUCCESS Review a Little Every Day.

Successful students find that review is not something you do the night before the test. Take time to review a little each day. When you are learning new material, take a little time to look over the concepts previously learned in the chapter. By this continual review you will find the pressure is reduced to prepare for a test. You need time to think about what you have learned and make sure you really understand it. This will help to tie together the different topics in the chapter. A little review of each idea and each kind of problem will enable you to feel confident. You will think more clearly and have less tension when it comes to test time.

Making it personal: Which of these suggestions is the one you most need to follow? On a separate sheet of paper, write down what you need to do to improve in this area.

1.2 Exercises MyLab™ Math

Verbal and Writing Skills, Exercises 1 and 2

1. Explain in your own words.

(a) the commutative property of addition

(b) the associative property of addition

2. When zero is added to any number, it does not change that number. Why do you think this is called the identity property of zero?

Complete the addition facts for each table on a separate sheet of paper. Strive for total accuracy, but work quickly. Allow a maximum of five minutes for each table.

3.

+	3	5	4	8	0	6	7	2	9	1
2										
7										
5										
3										
0										
4										
1										
8										
6										
9										

4.

+	1	6	5	3	0	9	4	7	2	8
3										
9										
4										
0										
2										
7										
8										
1										
6										
5										

Add.

5.
$$\begin{array}{r} 8 \\ 2 \\ 3 \\ +\ 7 \\ \hline \end{array}$$

6.
$$\begin{array}{r} 9 \\ 5 \\ 7 \\ +\ 2 \\ \hline \end{array}$$

7.
$$\begin{array}{r} 2 \\ 6 \\ 7 \\ 8 \\ +\ 3 \\ \hline \end{array}$$

8.
$$\begin{array}{r} 2 \\ 3 \\ 5 \\ 9 \\ +\ 8 \\ \hline \end{array}$$

9.
$$\begin{array}{r} 18 \\ 36 \\ +\ 3 \\ \hline \end{array}$$

10.
$$\begin{array}{r} 86 \\ 17 \\ +\ 4 \\ \hline \end{array}$$

11.
$$\begin{array}{r} 63 \\ 24 \\ +\ 12 \\ \hline \end{array}$$

12.
$$\begin{array}{r} 54 \\ 21 \\ +\ 23 \\ \hline \end{array}$$

13.
$$\begin{array}{r} 3315 \\ 726 \\ +\ 84 \\ \hline \end{array}$$

14.
$$\begin{array}{r} 5773 \\ 425 \\ +\ 67 \\ \hline \end{array}$$

15.
$$\begin{array}{r} 5631 \\ 2344 \\ +\ 2019 \\ \hline \end{array}$$

16.
$$\begin{array}{r} 5017 \\ 2984 \\ +\ 1328 \\ \hline \end{array}$$

17.
$$\begin{array}{r} 8235 \\ +\ 5626 \\ \hline \end{array}$$

18.
$$\begin{array}{r} 6753 \\ +\ 3265 \\ \hline \end{array}$$

19.
$$\begin{array}{r} 62{,}504 \\ +\ 54{,}736 \\ \hline \end{array}$$

20.
$$\begin{array}{r} 83{,}596 \\ +\ 56{,}384 \\ \hline \end{array}$$

Add from the top. Then check by adding in the reverse order.

21.
36
41
25
6
+ 13

22.
24
39
16
14
+ 9

23.
207
15
3
57
+ 861

24.
426
39
6
52
+ 802

Add.

25.
85
256
55
+ 9734

26.
582
1674
336
+ 8458

27.
1,362,214
7,002,316
+ 3,214,896

28.
4,002,983
2,134,702
+ 3,592,001

29.
837,241,000
+ 298,039,240

30.
982,306,000
+ 583,215,320

31.
516,208
24,317
+ 1,763,295

32.
32,500
763,420
+ 2,837,667

33. 25 + 130 + 70 + 75

34. 120 + 35 + 360 + 75

35. 107 + 40 + 76 + 55 + 30

36. 40 + 320 + 66 + 39 + 80

Applications

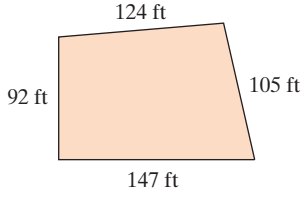
37. ***Consumer Mathematics*** Stephanie took her triplets shopping for the new school year. She spent $455 on clothes, $186 on shoes, and $82 on supplies. What was the total amount of money Stephanie spent?

38. ***Consumer Mathematics*** At the beginning of fall semester, Lexi purchased an iPad for $595, textbooks for $348, and other supplies for $76. What is the total amount that Lexi spent on school supplies?

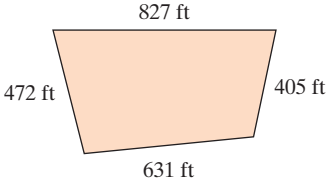
39. ***Personal Finance*** Stella works part time at a studio where she teaches music classes to children. Two months ago she earned $1875. Last month she made $1930 and this month she earned $1744. What is the total amount for the three months?

40. ***Personal Finance*** Paul is a soccer coach and teaches kids' classes in the summer. Last summer he earned $2025 in June, $2650 in July, and $1960 in August. What is the total amount Paul earned last summer?

▲ **41.** ***Geometry*** Nathaniel wants to put a fence around his backyard. The sketch below indicates the length of each side of the yard. What is the total number of feet of fence he needs for his backyard? (Find the perimeter of the yard.)



▲ **42.** ***Geometry*** Josiah has a field with the length of each side as labeled on the sketch. What is the total number of feet of fence that would be required to fence in the field? (Find the perimeter of the field.)



▲ **43.** ***Geography*** The largest island in the Atlantic Ocean is Greenland, with an area of 840,000 square miles. The second largest island, Great Britain, has an area of 88,407 square miles and the third largest is Iceland, with 39,699 square miles. What is the total area of these three islands?

▲ **44.** ***Geography*** The largest group of islands in the Pacific Ocean is the Japanese islands, with an area of 145,850 square miles. The second largest group of islands, the Philippine islands, has an area of 115,860 square miles. The third largest group is New Zealand, with 104,454 square miles. What is the total area of these groups of islands?

45. ***Geography*** The Nile River is Africa's longest river, measuring 7,272,320 yards. The second and third longest rivers in Africa are the Congo River, measuring 5,104,000 yards, and the Niger River, which measures 4,558,400 yards. What is the total length of these rivers?

▲ **46.** ***Geography*** The three largest of the Great Lakes are Lake Superior at 81,000 square miles, Lake Michigan at 67,900 square miles, and Lake Huron at 74,700 square miles. What is the total area of these three lakes?

In exercises 47–48, be sure you understand the problem and then choose the numbers you need in order to answer each question. Then solve the problem.

47. ***Education*** The admissions department of a competitive university is reviewing applications to see whether students are *eligible* or *ineligible* for student aid. On Monday, 415 were found eligible and 27 ineligible. On Tuesday, 364 were found eligible and 68 ineligible. On Wednesday, 159 were found eligible and 102 ineligible. On Thursday, 196 were found eligible and 61 ineligible.

(a) How many students were eligible for student aid over the four days?

(b) How many students were considered in all?

48. ***Manufacturing*** The quality control division of a motorcycle company classifies the final assembled bike as *passing* or *failing* final inspection. In January, 14,311 vehicles passed whereas 56 failed. In February, 11,077 passed and 158 failed. In March, 12,580 passed and 97 failed.

(a) How many motorcycles passed the inspection during the three months?

(b) In the three months, how many motorcycles were assembled in all?

Use the following facts to solve exercises 49 and 50. It is 87 miles from Springfield to Weston. It is 17 miles from Weston to Boston. Driving directly, it is 98 miles from Springfield to Boston. It is 21 miles from Boston to Hamilton.

49. ***Geography*** If Melissa drives from Springfield to Weston, then from Weston to Boston, and finally directly home to Springfield, how many miles does she drive?

50. ***Geography*** If Marcia drives from Hamilton to Boston, then from Boston to Weston, and then from Weston to Springfield, how many miles does she drive?

▲ **51.** ***Geometry*** Walter Swensen is examining the fences of a farm in Caribou, Maine. One field is in the shape of a four-sided figure with no sides equal. The first side is 568 feet long, while the second side is 682 feet long. The third side is 703 feet long. The fourth side is 434 feet long. How long is the fence enclosing this field?

▲ **52.** ***Geometry*** Carlos Sontera is riding to examine the fences of a ranch in El Paso, Texas. The field he is examining is in the shape of a rectangle. One side of the rectangle is 930 feet long. The adjacent side is 798 feet long. How much fencing is used to enclose this field? (*Hint:* The opposite sides of a rectangle are equal.)

53. ***Personal Finance*** Answer using the information in the following Western University expense chart for the current academic year.

Western University Yearly Expenses	In-State Student, U.S. Citizen	Out-of-State Student, U.S. Citizen	Foreign Student
Tuition	$3640	$5276	$8352
Room	1926	2437	2855
Board	1753	1840	1840

How much is the total cost for tuition, room, and board for

(a) an out-of-state U.S. citizen?

(b) an in-state U.S. citizen?

(c) a foreign student?

To Think About *In exercises 54–55, add.*

54. 2,368,521,788 + 5,721,368,701 + 4,027,399,206

55. 89 + 166 + 23 + 45 + 72 + 190 + 203 + 77 + 18 + 93 + 46 + 73 + 66

56. What would happen if addition were not commutative?

57. What would happen if addition were not associative?

Cumulative Review *Write the word name for each number.*

58. **[1.1.3]** 76,208,941

59. **[1.1.3]** 121,000,374

Write each number in standard notation.

60. **[1.1.3]** eight million, seven hundred twenty-four thousand, three hundred ninety-six

61. **[1.1.3]** nine million, fifty-one thousand, seven hundred nineteen

62. **[1.1.3]** twenty-eight million, three hundred eighty-seven thousand, eighteen

Quick Quiz 1.2 *Add.*

1.
$$\begin{array}{r} 56 \\ 38 \\ 92 \\ 17 \\ +\ \ 9 \\ \hline \end{array}$$

2.
$$\begin{array}{r} 831 \\ 276 \\ +\ 508 \\ \hline \end{array}$$

3.
$$\begin{array}{r} 681{,}302 \\ 5{,}126 \\ 18{,}371 \\ +\ 300{,}012 \\ \hline \end{array}$$

4. **Concept Check** Explain how you would use carrying when performing the following calculation: 4567 + 3189 + 895.

1.3 Subtracting Whole Numbers

1 Mastering Basic Subtraction Facts

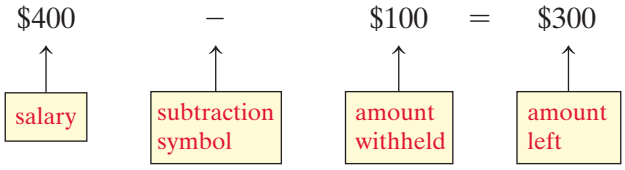
Subtraction is used day after day in the business world. The owner of a bakery placed an ad for his cakes in a local newspaper to see if this might increase his profits. To learn how many cakes had been sold, at closing time he subtracted the number of cakes remaining from the number of cakes the bakery had when it opened. To figure his profits, he subtracted his costs (including the cost of the ad) from his sales. Finally, to see if the ad paid off, he subtracted the profits he usually made in that period from the profits after advertising. He needed subtraction to see whether it paid to advertise.

What is subtraction? We do subtraction when we take objects away from a group. If you have 12 objects and take away 3 of them, 9 objects remain.

12 objects − 3 objects = 9 objects

$$12 - 3 = 9$$

If you earn \$400 per month but have \$100 taken out for taxes, how much do you have left?

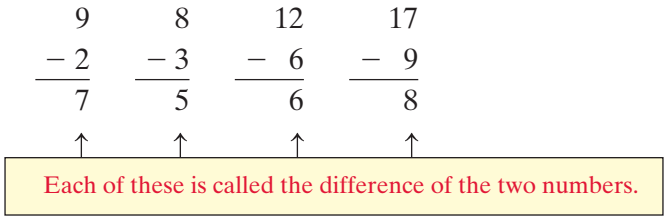


We can use addition to help with a subtraction problem.

To subtract: $200 - 196 =$ what number

We can think: $196 +$ what number $= 200$

Usually when we subtract numbers, we put one number under the other in a column. When we subtract one number from another, the answer is called the **difference.**



The other two parts of a subtraction problem have labels, although you will not often come across them. The number being subtracted is called the **subtrahend.** The number being subtracted from is called the **minuend.**

$$\begin{array}{rl} 17 & \text{minuend} \\ -\ 9 & \text{subtrahend} \\ \hline 8 & \text{difference} \end{array}$$

In this case, the number 17 is called the *minuend.* The number 9 is called the *subtrahend.* The number 8 is called the *difference.*

Student Learning Objectives

After studying this section, you will be able to:

1. Master basic subtraction facts.
2. Subtract whole numbers when borrowing is not necessary.
3. Subtract whole numbers when borrowing is necessary. GUIDED LEARNING VIDEO
4. Check the answer to a subtraction problem.
5. Apply subtraction to real-life situations. GUIDED LEARNING VIDEO

Quick Recall of Subtraction Facts It is helpful if you can subtract quickly. See if you can do Example 1 correctly in 15 seconds or less. Repeat again with Student Practice 1. Strive to obtain all answers correctly in 15 seconds or less.

Example 1 Subtract.

(a) $8 - 2$ **(b)** $13 - 5$ **(c)** $12 - 4$

(d) $15 - 8$ **(e)** $16 - 0$

Solution

(a) $\begin{array}{r} 8 \\ -\ 2 \\ \hline 6 \end{array}$ **(b)** $\begin{array}{r} 13 \\ -\ 5 \\ \hline 8 \end{array}$ **(c)** $\begin{array}{r} 12 \\ -\ 4 \\ \hline 8 \end{array}$

(d) $\begin{array}{r} 15 \\ -\ 8 \\ \hline 7 \end{array}$ **(e)** $\begin{array}{r} 16 \\ -\ 0 \\ \hline 16 \end{array}$ □

Student Practice 1

Subtract.

(a) $\begin{array}{r} 9 \\ -\ 6 \\ \hline \end{array}$ **(b)** $\begin{array}{r} 12 \\ -\ 5 \\ \hline \end{array}$ **(c)** $\begin{array}{r} 17 \\ -\ 8 \\ \hline \end{array}$ **(d)** $\begin{array}{r} 14 \\ -\ 0 \\ \hline \end{array}$ **(e)** $\begin{array}{r} 18 \\ -\ 9 \\ \hline \end{array}$

2 Subtracting Whole Numbers When Borrowing Is Not Necessary

When we subtract numbers with more than two digits, in order to keep track of our work, we line up the ones column, the tens column, the hundreds column, and so on. Note that we begin with the ones column and move from right to left.

Example 2 Subtract. $9867 - 3725$

Solution

$$\begin{array}{r} 9\ 8\ 6\ 7 \\ -\ 3\ 7\ 2\ 5 \\ \hline 6\ 1\ 4\ 2 \end{array}$$

7 ones − 5 ones = 2 ones

6 tens − 2 tens = 4 tens

8 hundreds − 7 hundreds = 1 hundred

9 thousands − 3 thousands = 6 thousands □

Student Practice 2

Subtract. $7695 - 3481$

3 Subtracting Whole Numbers When Borrowing Is Necessary

GUIDED LEARNING VIDEO

In the subtraction that we have looked at so far, each digit in the upper number (the minuend) has been greater than the digit in the lower number (the subtrahend) for each place value. Many times, however, a digit in the lower number is greater than the digit in the upper number for that place value.

$$\begin{array}{r} 42 \\ -\ 28 \\ \hline \end{array}$$

The digit in the ones place in the lower number, the 8 of 28, is greater than the number in the ones place in the upper number, the 2 of 42. To subtract, we must *rename* 42, using place values. This is called **borrowing.**

Example 3 Subtract. $42 - 28$

Solution

$$\begin{array}{r} {\scriptstyle 3\ \ 12} \\ 4\ \ \not{2} \\ -\ 2\ \ 8 \\ \hline 1\ \ 4 \end{array}$$

To subtract 8 ones from 2 ones, we need to borrow. Since 1 ten is 10 ones, we can rename 42 as 3 tens and 12 ones, writing the 3 in the tens column and the 12 in the ones column.

Now we subtract 8 ones from 12 ones to obtain 4 ones.

We then subtract 2 tens from 3 tens to obtain 1 ten.

□

Student Practice 3

Subtract. $34 - 16$

Example 4 Subtract. $864 - 548$

Solution

$$\begin{array}{r} {\scriptstyle 5\ \ 14} \\ 8\ \not{6}\ \not{4} \\ -\ 5\ 4\ 8 \\ \hline 3\ 1\ 6 \end{array}$$

To subtract 8 ones from 4 ones, we borrow 1 ten from the 6 tens and write 5 in the tens column to show what is left. Since we are borrowing 1 ten, which is 10 ones, we now have 14 ones and write 14 in the ones column.

Now we subtract 8 ones from 14 ones to obtain 6 ones.

We continue to subtract from right to left.

□

Student Practice 4

Subtract.

$$\begin{array}{r} 693 \\ -\ 426 \\ \hline \end{array}$$

Student Practice 5

Subtract. 9070 − 5886

For all Student Practice problems, write out the steps on a separate sheet of paper. Check the step-by-step solutions in the back of the textbook.

Example 5 Subtract. 8040 − 6375

Solution

$$\begin{array}{r} {\scriptstyle 7\ \ 9\ \ 13\ \ 10} \\ \not{8}\ \not{0}\ \not{4}\ \not{0} \\ -\ 6\ 3\ 7\ 5 \\ \hline 1\ 6\ 6\ 5 \end{array}$$

To subtract 5 from 0, we borrow 1 ten from the 4 tens to make 3 tens and 10 ones. 10 − 5 = 5

To subtract 7 tens from the 3 tens, we need to borrow 1 hundred to make 10 tens. Since we find a 0 in the hundreds column, first we borrow 1 thousand to make 10 hundreds. We show the number of thousands that are left and write the 10 in the hundreds column. Now we borrow 1 hundred, show the number of hundreds that are left, and add the 10 tens to the 3 tens. We now do the subtraction. 13 tens − 7 tens = 6 tens

9 hundreds − 3 hundreds = 6 hundreds

7 thousands − 6 thousands = 1 thousand

Example 6 Subtract.

(a) 9521 − 943 **(b)** 40,000 − 29,056

Solution

(a)
$$\begin{array}{r} {\scriptstyle 8\ \ 14\ \ 11\ \ 11} \\ \not{9}\ \not{5}\ \not{2}\ \not{1} \\ -\ \ 9\ 4\ 3 \\ \hline 8\ 5\ 7\ 8 \end{array}$$

(b)
$$\begin{array}{r} {\scriptstyle 3\ \ 9\ \ 9\ \ 9\ \ 10} \\ \not{4}\ \not{0},\ \not{0}\ \not{0}\ \not{0} \\ -\ 2\ 9,\ 0\ 5\ 6 \\ \hline 1\ 0,\ 9\ 4\ 4 \end{array}$$

Student Practice 6

Subtract.

(a)
$$\begin{array}{r} 8964 \\ -\ \ 985 \\ \hline \end{array}$$

(b)
$$\begin{array}{r} 50{,}000 \\ -\ 32{,}508 \\ \hline \end{array}$$

4 Checking the Answer to a Subtraction Problem

We observe that when 9 − 7 = 2 it follows that 7 + 2 = 9. Each subtraction problem is equivalent to a corresponding addition problem. This gives us a convenient way to check our answers to subtraction.

Example 7 Check this subtraction problem.

$$5829 - 3647 = 2182$$

Solution

$$\begin{array}{r} 5\ 8\ 2\ 9 \\ -\ 3\ 6\ 4\ 7 \\ \hline 2\ 1\ 8\ 2 \end{array}$$

The sum should equal 5829, which it does. We have checked our work, and it is correct.

then

$$\begin{array}{r} 3\ 6\ 4\ 7 \\ +\ 2\ 1\ 8\ 2 \\ \hline 5\ 8\ 2\ 9 \end{array}$$

□

Student Practice 7

Check this subtraction problem.

$$9763 - 5732 = 4031$$

Example 8 Subtract and check your answers.

(a) 156,000 − 29,326 **(b)** 1,264,308 − 1,057,612

Solution

(a)

$$\begin{array}{r} 156{,}000 \\ -\ 29{,}326 \\ \hline 126{,}674 \end{array}$$

It checks.

$$\begin{array}{r} 29{,}326 \\ +\ 126{,}674 \\ \hline 156{,}000 \end{array}$$

(b)

$$\begin{array}{r} 1{,}264{,}308 \\ -\ 1{,}057{,}612 \\ \hline 206{,}696 \end{array}$$

It checks.

$$\begin{array}{r} 1{,}057{,}612 \\ +\ 206{,}696 \\ \hline 1{,}264{,}308 \end{array}$$

□

Student Practice 8

Subtract and check your answers.

(a)

$$\begin{array}{r} 284{,}000 \\ -\ 96{,}327 \\ \hline \end{array}$$

(b)

$$\begin{array}{r} 8{,}526{,}024 \\ -\ 6{,}397{,}518 \\ \hline \end{array}$$

Subtraction can be used to solve word problems. Some problems can be expressed (and solved) with an **equation.** An equation is a number sentence with an equals sign, such as

$$10 = 4 + x$$

Here we use the letter x to represent a number we do not know. When we write $10 = 4 + x$, we are stating that 10 is equal to 4 added to some other number. Since $10 - 4 = 6$, we would assume that the number is 6. If we substitute 6 for x in the equation, we have two values that are the same.

$$10 = 4 + x$$
$$10 = 4 + 6 \quad \text{Substitute 6 for } x.$$
$$10 = 10 \quad \text{Both sides of the equation are the same.}$$

We can write an equation when one of the addends is not known, then use subtraction to solve for the unknown.

Example 9 The librarian knows that he has eight world atlases and that five of them are in full color. How many are not in full color?

Solution We represent the number that we don't know as x and write an equation, or mathematical sentence.

$$8 = 5 + x$$

To solve an equation means to find those values that will make the equation true. We solve this equation by reasoning and by a knowledge of the relationship between addition and subtraction.

$$8 = 5 + x \text{ is equivalent to } 8 - 5 = x$$

We know that $8 - 5 = 3$. Then $x = 3$. We can check the answer by substituting 3 for x in the original equation.

$$8 = 5 + x$$
$$8 = 5 + 3 \quad \text{True } ✓$$

We see that $x = 3$ checks, so our answer is correct. There are three atlases not in full color. □

Student Practice 9

Form an equation for each of the following problems. Solve the equation in order to answer the question.

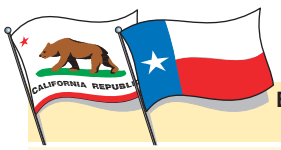
(a) The Salem Harbormaster's daily log noted that seventeen fishing vessels left the harbor yesterday during daylight hours. Walter was at the harbor all morning and saw twelve fishing vessels leave in the morning. How many vessels left in the afternoon? (Assume that sunset was at 6 P.M.)

(b) The Appalachian Mountain Club noted that twenty-two hikers left to climb Mount Washington during the morning. By 4 P.M., ten of them had returned. How many of the hikers were still on the mountain?

5 Applying Subtraction to Real-Life Situations

We use subtraction in all kinds of situations. There are several key words in word problems that imply subtraction. Words that involve comparison, such as *how much more, how much greater,* or how much a quantity *increased* or *decreased,* all imply subtraction. The *difference* between two numbers implies subtraction.

Example 10 Look at the following population table.

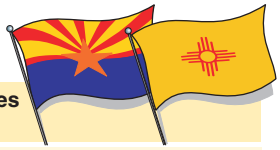


Estimated Population of Four States from 1970 to 2020

State	1970	1980	1990	2000	2010	2020*
California	19,971,069	23,667,947	29,760,021	33,872,675	38,067,134	39,874,134
Texas	11,198,655	14,227,799	16,986,510	20,852,366	24,648,888	29,452,944
Arizona	1,775,399	2,716,598	3,665,228	5,131,037	6,637,381	7,417,555
New Mexico	1,017,055	1,303,302	1,515,069	1,819,429	1,980,225	2,099,621

*estimated

Source: U.S. Bureau of the Census



(a) In 1980, how much greater was the population of Texas than that of Arizona?

(b) How much did the population of California increase from 1970 to 2010?

(c) How much greater was the population of California in 2010 than that of the other three states combined?

Solution

(a)
$$\begin{array}{rl} 14{,}227{,}799 & \text{1980 population of Texas} \\ -\ 2{,}716{,}598 & \text{1980 population of Arizona} \\ \hline 11{,}511{,}201 & \text{difference} \end{array}$$

The population of Texas was greater by 11,511,201.

(b)
$$\begin{array}{rl} 38{,}067{,}134 & \text{2010 population of California} \\ -\ 19{,}971{,}069 & \text{1970 population of California} \\ \hline 18{,}096{,}065 & \text{difference} \end{array}$$

The population of California increased by 18,096,065 in those 40 years.

(c) First we need to find the total population in 2010 of Texas, Arizona, and New Mexico.

$$\begin{array}{rl} 24{,}648{,}888 & \text{2010 population of Texas} \\ 6{,}637{,}381 & \text{2010 population of Arizona} \\ +\ 1{,}980{,}225 & \text{2010 population of New Mexico} \\ \hline 33{,}266{,}494 & \end{array}$$

We use subtraction to compare this total with the population of California.

$$\begin{array}{rl} 38{,}067{,}134 & \text{2010 population of California} \\ -\ 33{,}266{,}494 & \\ \hline 4{,}800{,}640 & \end{array}$$

The population of California in 2010 was 4,800,640 more than the population of the other three states combined. □

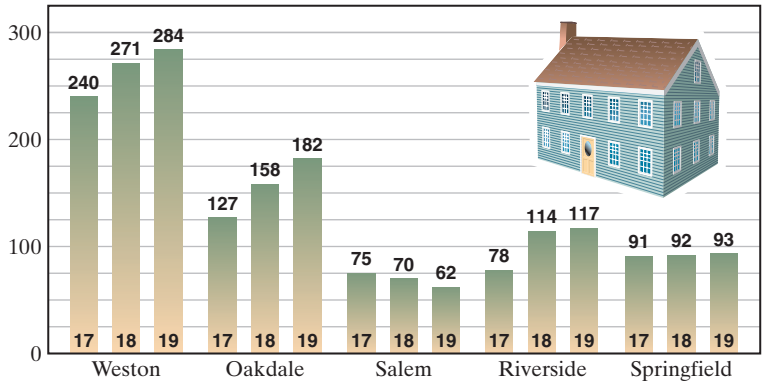
Student Practice 10

Based on the preceding population table, answer the following questions.

(a) In 2020, the estimated population of California was how much greater than the estimated population of Texas?

(b) How much did the population of Texas increase from 1970 to 1980?

Example 11 The number of residential real estate transfers in several towns during the years 2017 to 2019 is given in the following bar graph.



(a) What was the increase in homes sold in Weston from 2018 to 2019?

(b) What was the decrease in homes sold in Salem from 2017 to 2019?

(c) Between what two years did Oakdale have the greatest increase in sales?

Solution

(a) From the labels on the bar graph we see that 284 homes were sold in 2019 in Weston and 271 homes were sold in 2018. Thus the increase can be found by subtracting $284 - 271 = 13$. There was an increase of 13 homes sold in Weston from 2018 to 2019.

(b) In 2017, 75 homes were sold in Salem. In 2019, 62 homes were sold in Salem. The decrease in the number of homes sold is $75 - 62 = 13$. There was a decrease of 13 homes sold in Salem from 2017 to 2019.

(c) Here we will need to make two calculations in order to decide where the greatest increase occurs.

158	2018 sales	182	2019 sales
− 127	2017 sales	− 158	2018 sales
31	Sales increase from 2017 to 2018	24	Sales increase from 2018 to 2019

The greatest increase in sales in Oakdale occurred from 2017 to 2018. □

Student Practice 11

Based on the preceding bar graph, answer the following questions.

(a) What was the increase in homes sold in Riverside from 2017 to 2018?

(b) How many more homes were sold in Springfield in 2017 than in Riverside in 2017?

(c) Between what two years did Weston have the greatest increase in sales?

1.3 Exercises MyLab™ Math

Verbal and Writing Skills, Exercises 1–4

1. Explain how you can check a subtraction problem.

2. Explain how you use borrowing to calculate $107 - 88$.

3. Explain what number should be used to replace the question mark in the subtraction equation $32?5 - 1683 = 1592$.

4. Explain what steps need to be done to calculate 7 feet − 11 inches.

Try to do exercises 5–20 in one minute or less with no errors.

Subtract.

5. $\begin{array}{r} 9 \\ -\ 4 \\ \hline \end{array}$

6. $\begin{array}{r} 16 \\ -\ 7 \\ \hline \end{array}$

7. $\begin{array}{r} 15 \\ -\ 9 \\ \hline \end{array}$

8. $\begin{array}{r} 15 \\ -\ 8 \\ \hline \end{array}$

9. $\begin{array}{r} 16 \\ -\ 0 \\ \hline \end{array}$

10. $\begin{array}{r} 14 \\ -\ 6 \\ \hline \end{array}$

11. $\begin{array}{r} 18 \\ -\ 9 \\ \hline \end{array}$

12. $\begin{array}{r} 12 \\ -\ 7 \\ \hline \end{array}$

13. $\begin{array}{r} 11 \\ -\ 4 \\ \hline \end{array}$

14. $\begin{array}{r} 15 \\ -\ 8 \\ \hline \end{array}$

15. $\begin{array}{r} 13 \\ -\ 7 \\ \hline \end{array}$

16. $\begin{array}{r} 16 \\ -\ 9 \\ \hline \end{array}$

17. $\begin{array}{r} 11 \\ -\ 8 \\ \hline \end{array}$

18. $\begin{array}{r} 10 \\ -\ 7 \\ \hline \end{array}$

19. $\begin{array}{r} 15 \\ -\ 6 \\ \hline \end{array}$

20. $\begin{array}{r} 12 \\ -\ 5 \\ \hline \end{array}$

Subtract. Check your answers by adding.

21. $\begin{array}{r} 47 \\ -\ 26 \\ \hline \end{array}$

22. $\begin{array}{r} 96 \\ -\ 51 \\ \hline \end{array}$

23. $\begin{array}{r} 85 \\ -\ 73 \\ \hline \end{array}$

24. $\begin{array}{r} 77 \\ -\ 36 \\ \hline \end{array}$

25. $\begin{array}{r} 379 \\ -\ 36 \\ \hline \end{array}$

26. $\begin{array}{r} 189 \\ -\ 65 \\ \hline \end{array}$

27. $\begin{array}{r} 869 \\ -\ 548 \\ \hline \end{array}$

28. $\begin{array}{r} 659 \\ -\ 247 \\ \hline \end{array}$

29. $\begin{array}{r} 4799 \\ -\ 596 \\ \hline \end{array}$

30. $\begin{array}{r} 5780 \\ -\ 530 \\ \hline \end{array}$

31. $\begin{array}{r} 155{,}835 \\ -\ 12{,}600 \\ \hline \end{array}$

32. $\begin{array}{r} 243{,}951 \\ -\ 12{,}400 \\ \hline \end{array}$

33. $\begin{array}{r} 986{,}302 \\ -\ 433{,}201 \\ \hline \end{array}$

34. $\begin{array}{r} 807{,}965 \\ -\ 304{,}214 \\ \hline \end{array}$

Check each subtraction. If the problem has not been done correctly, find the correct answer.

35. 129 − 19 = 110

36. 186 − 45 = 141

37. 8596 − 3215 = 5781

38. 9956 − 7254 = 2702

39. 6030 − 5020 = 1020

40. 7890 − 3200 = 7670

41. 47,869 − 33,846 = 13,023

42. 99,583 − 41,181 = 58,402

Subtract. Use borrowing if necessary.

43. 98 − 52

44. 86 − 33

45. 174 − 82

46. 136 − 95

47. 647 − 263

48. 706 − 435

49. 9055 − 2137

50. 8261 − 3745

51. 20,000 − 9285

52. 50,000 − 7338

53. 152,000 − 117,908

54. 361,000 − 121,520

55. 45,312 − 37,865

56. 64,381 − 29,997

57. 2,378,862 − 1,469,932

58. 3,554,830 − 1,710,913

Solve.

59. $x + 14 = 19$

60. $x + 35 = 50$

61. $28 = x + 20$

62. $25 = x + 18$

63. $100 + x = 127$

64. $140 + x = 200$

Applications

65. ***Current Events*** In the 2016 presidential election, a total of 8,562,915 votes were cast in Texas for either Democrat Hillary Clinton or Republican Donald Trump. If Trump received 4,685,047 votes, how many did Clinton receive?

66. ***Current Events*** In the 2016 presidential election, a total of 6,784,444 votes were cast in New York State for either Democrat Hillary Clinton or Republican Donald Trump. If Clinton received 4,143,874 votes, how many did Trump receive?

67. ***Population Trends*** In 2019, the population of Ireland was approximately 4,832,980. In the same year, the population of Portugal was approximately 10,254,666. How much less than the population of Portugal was the population of Ireland?

68. ***Geography*** The Nile River, the longest river in the world, is approximately 22,070,400 feet long. The Yangtze Kiang River, which is the longest river in China, is approximately 19,018,560 feet long. How much longer is the Nile River than the Yangtze Kiang River?

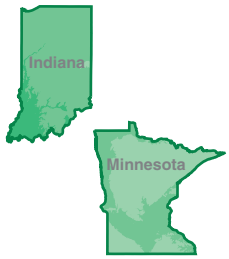
69. ***Personal Finance*** Michaela's gross pay on her last paycheck was $2880. Her deductions totaled $636 and she deposited $300 into her savings account. She put the remaining amount into her debit account to pay bills. How much did Michaela put into her debit account?

70. ***Personal Finance*** Adam earned $3450 last summer at his construction job. He owed his brother $375 and saved $2300 to pay for his college tuition. He used the remaining amount as a down payment for a car. How much did Adam have for the down payment?

Population Trends *In answering exercises 71–78, consider the following population table.*

	1970	1980	1990	2000	2010	2020*
Illinois	11,110,285	11,427,409	11,430,602	12,051,683	12,916,894	12,639,355
Michigan	8,881,826	9,262,044	9,295,297	9,679,052	10,428,683	10,035,938
Indiana	5,195,392	5,490,212	5,544,159	6,045,521	6,392,139	6,758,964
Minnesota	3,806,103	4,075,970	4,375,099	4,830,784	5,420,636	5,701,317

Source: U.S. Census Bureau *estimated



71. How much did the population of Minnesota increase from 1970 to 2010?

72. How much did the population of Michigan increase from 1970 to 2010?

73. In 1970, how much greater was the population of Illinois than the populations of Indiana and Minnesota combined?

74. In 2000, how much greater was the population of Illinois than the populations of Indiana and Minnesota combined?

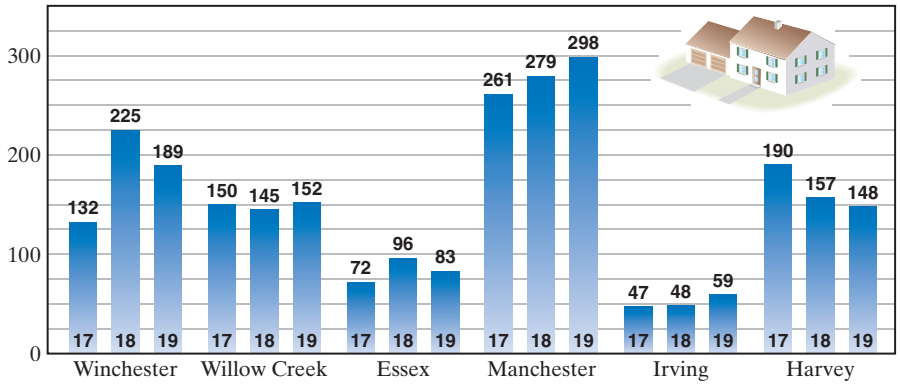
75. How much did the population of Illinois increase from 1970 to 1990?

76. How much did the population of Michigan increase from 1970 to 1990?

77. Compare your answers to exercises 75 and 76. How much greater was the population increase of Michigan than the population increase of Illinois from 1970 to 1990?

78. In 2020, what will be the difference in population between the state with the highest population and the state with the lowest population?

Real Estate *The number of real estate transfers in several towns during the years 2017 to 2019 is given in the following bar graph. Use the bar graph to answer exercises 79–86. The figures in the bar graph reflect sales of single-family detached homes only.*



79. What was the increase in the number of homes sold in Winchester from 2017 to 2018?

80. What was the increase in the number of homes sold in Irving from 2018 to 2019?

81. What was the decrease in the number of homes sold in Essex from 2018 to 2019?

82. What was the decrease in the number of homes sold in Harvey from 2017 to 2018?

83. Between what two years did the greatest change occur in the number of homes sold in Willow Creek?

84. Between what two years did the greatest change occur in the number of homes sold in Manchester?

85. A real estate agent was trying to determine which two towns were closest to having the same number of sales in 2019. Which two towns should she select?

86. A real estate agent was trying to determine which two towns were closest to having the same number of sales in 2017. Which two towns should he select?

To Think About

87. In general, subtraction is not commutative. If a and b are whole numbers, $a - b \neq b - a$. For what types of numbers would it be true that $a - b = b - a$?

88. In general, subtraction is not associative. For example, $8 - (4 - 3) \neq (8 - 4) - 3$. In general, $a - (b - c) \neq (a - b) - c$. Can you find some numbers a, b, c for which $a - (b - c) = (a - b) - c$? (Remember, do operations inside the parentheses first.)

89. ***Consumer Mathematics*** Walter Swensen wants to replace some of the fences on a farm in Caribou, Maine. The wooden rail fence costs about $60 for wood and $50 for labor to install a fence that is 12 feet long. His son estimates he would need 276 feet of new fence. However, when he measures it he realizes he only needs 216 new feet of fence. What is the difference in cost of his son's estimate versus his estimate with regard to how many feet of fence are needed?

90. ***Consumer Mathematics*** Carlos Sontera is replacing an expensive barbed-wire fence on a ranch in El Paso, Texas. The barbed wire and poles for 12 feet of fence cost about $80. The labor cost to install 12 feet of fence is about $40. A ranch hand reports that 300 new feet of fence are needed. However, when Carlos actually rides out there and measures it, he finds that only 228 new feet of fence are needed. What is the difference in cost of the ranch hand's estimate versus Carlos's estimate of how many feet of fence are needed?

Cumulative Review

91. **[1.1.3]** Write in standard notation: eight million, four hundred sixty-six thousand, eighty-four

92. **[1.1.3]** Write the word name for 296,308.

93. **[1.2.4]** Add. $25 + 75 + 80 + 20 + 18$

94. **[1.2.4]** Add.
$$\begin{array}{r} 278{,}563 \\ +\ 896{,}187 \\ \hline \end{array}$$

Quick Quiz 1.3 *Subtract.*

1.
$$\begin{array}{r} 5392 \\ -\ 938 \\ \hline \end{array}$$

2.
$$\begin{array}{r} 609{,}240 \\ -\ 386{,}307 \\ \hline \end{array}$$

3.
$$\begin{array}{r} 17{,}200{,}300 \\ -\ 11{,}562{,}178 \\ \hline \end{array}$$

4. Concept Check Explain how you would use borrowing when performing the calculation $12{,}345 - 11{,}976$.

1.4 Multiplying Whole Numbers

1 Mastering Basic Multiplication Facts

Like subtraction, multiplication is related to addition. Suppose that the pastry chef at the Gourmet Restaurant bakes croissants on a sheet that holds four croissants across, with room for three rows. How many croissants does the sheet hold?

We can add $4 + 4 + 4$ to get the total, or we can use a shortcut: three rows of four is the same as 3 times 4, which equals 12. This is **multiplication,** a shortcut for repeated addition.

The numbers that we multiply are called **factors.** The answer is called the **product.** For now, we will use $\times$ to show multiplication. 3×4 is read "three times four."

$$\underbrace{3}_{\text{factor}} \times \underbrace{4}_{\text{factor}} = \underbrace{12}_{\text{product}} \qquad \begin{array}{r} 3 \text{ factor} \\ \times\ 4 \text{ factor} \\ \hline 12 \text{ product} \end{array}$$

Your skill in multiplication depends on how well you know the basic multiplication facts. Look at the table on page 36. You should learn these facts well enough to quickly and correctly give the products of any two factors in the table. To check your knowledge, try Exercises 1.4, exercises 3 and 4.

Study the table to see if you can discover any properties of multiplication. What do you see as results when you multiply zero by any number? When you multiply any number times zero, the result is zero. That is the **multiplication property of zero.**

$$2 \times 0 = 0 \qquad 5 \times 0 = 0 \qquad 0 \times 6 = 0 \qquad 0 \times 0 = 0$$

You may recall that zero plays a special role in addition. Zero is the *identity element* for addition. When we add any number to zero, that number does not change. Is there an identity element for multiplication? Look at the table. What is the identity element for multiplication? Do you see that it is 1? The **identity element for multiplication** is 1.

$$5 \times 1 = 5 \qquad 1 \times 5 = 5$$

What other properties of addition hold for multiplication? Is multiplication commutative? Does the order in which you multiply two numbers change the results? Find the product of 3×4. Then find the product of 4×3.

$$3 \times 4 = 12$$
$$4 \times 3 = 12$$

The **commutative property of multiplication** tells us that when we multiply two numbers, changing the order of the numbers gives the same result.

Student Learning Objectives

After studying this section, you will be able to:

1. Master basic multiplication facts.
2. Multiply a single-digit number by a several-digit number.
3. Multiply a whole number by a power of 10. GUIDED LEARNING VIDEO
4. Multiply a several-digit number by a several-digit number. GUIDED LEARNING VIDEO
5. Use the properties of multiplication to perform calculations.
6. Apply multiplication to real-life situations. GUIDED LEARNING VIDEO

Basic Multiplication Facts

×	0	1	2	3	4	5	6	7	8	9	10	11	12
0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	1	2	3	4	5	6	7	8	9	10	11	12
2	0	2	4	6	8	10	12	14	16	18	20	22	24
3	0	3	6	9	12	15	18	21	24	27	30	33	36
4	0	4	8	12	16	20	24	28	32	36	40	44	48
5	0	5	10	15	20	25	30	35	40	45	50	55	60
6	0	6	12	18	24	30	36	42	48	54	60	66	72
7	0	7	14	21	28	35	42	49	56	63	70	77	84
8	0	8	16	24	32	40	48	56	64	72	80	88	96
9	0	9	18	27	36	45	54	63	72	81	90	99	108
10	0	10	20	30	40	50	60	70	80	90	100	110	120
11	0	11	22	33	44	55	66	77	88	99	110	121	132
12	0	12	24	36	48	60	72	84	96	108	120	132	144

Quick Recall of Multiplication Facts It is helpful if you can multiply quickly. See if you can do Example 1 correctly in 15 seconds or less. Repeat again with Student Practice 1. Strive to obtain all answers correctly in 15 seconds or less.

Example 1 Multiply.

(a) 5×7 **(b)** 8×9 **(c)** 6×8

(d) 9×3 **(e)** 7×8

Solution

(a)
$$\begin{array}{r} 5 \\ \times\ 7 \\ \hline 35 \end{array}$$

(b)
$$\begin{array}{r} 8 \\ \times\ 9 \\ \hline 72 \end{array}$$

(c)
$$\begin{array}{r} 6 \\ \times\ 8 \\ \hline 48 \end{array}$$

(d)
$$\begin{array}{r} 9 \\ \times\ 3 \\ \hline 27 \end{array}$$

(e)
$$\begin{array}{r} 7 \\ \times\ 8 \\ \hline 56 \end{array}$$

□

Student Practice 1

Multiply.

(a)
$$\begin{array}{r} 8 \\ \times\ 8 \\ \hline \end{array}$$

(b)
$$\begin{array}{r} 7 \\ \times\ 6 \\ \hline \end{array}$$

(c)
$$\begin{array}{r} 5 \\ \times\ 8 \\ \hline \end{array}$$

(d)
$$\begin{array}{r} 9 \\ \times\ 7 \\ \hline \end{array}$$

(e)
$$\begin{array}{r} 9 \\ \times\ 9 \\ \hline \end{array}$$

2 Multiplying a Single-Digit Number by a Several-Digit Number

Example 2 Multiply. 4312×2

Solution We first multiply the ones column, then the tens column, and so on, moving right to left.

$$\begin{array}{r} 4\ 3\ 1\ 2 \\ \times \qquad 2 \\ \hline 8\ 6\ 2\ 4 \end{array}$$

$2 \times 2 = 4$ in the ones column

$2 \times 1 = 2$ in the tens column

$2 \times 3 = 6$ in the hundreds column

$2 \times 4 = 8$ in the thousands column

□

Student Practice 2

Multiply. 3021×3

Usually, we will have to carry one digit of the result of some of the multiplication into the next column on the left.

Example 3 Multiply. 36×7

Solution

$$\begin{array}{r} {\scriptstyle 4} \\ 3\ 6 \\ \times \quad 7 \\ \hline 2\ 5\ 2 \end{array}$$

carry number = 4

$7 \times 6 = 42$. Leave the 2 in the ones column and carry the 4 to the tens column.

7×3 tens $= 21$ tens. Add 21 tens + 4 tens to obtain 25 tens or 2 hundreds + 5 tens.

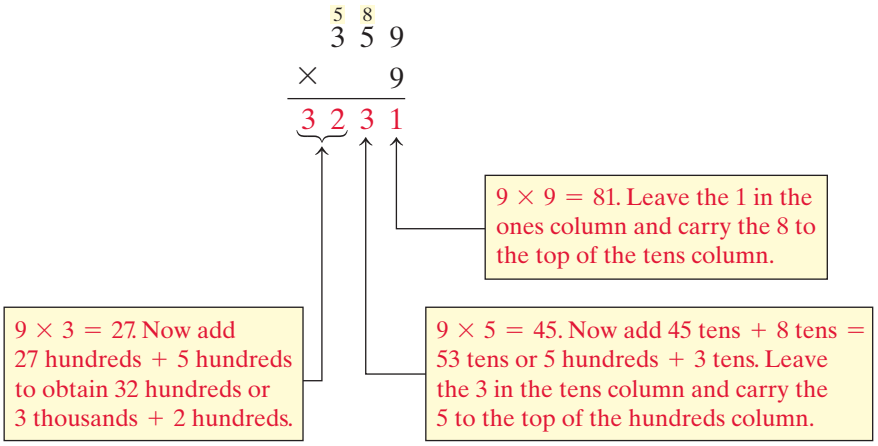
□

Student Practice 3

Multiply. 43×8

Example 4 Multiply. 359×9

Solution



Student Practice 4

Multiply. 579×7

3 Multiplying a Whole Number by a Power of 10

GUIDED LEARNING VIDEO

Observe what happens when a number is multiplied by 10, 100, 1000, 10,000, and so on.

$56 \times 10 = 560$ (one zero)

$56 \times 100 = 5600$ (two zeros)

$56 \times 1000 = 56{,}000$ (three zeros)

$56 \times 10{,}000 = 560{,}000$ (four zeros)

A **power of 10** is a whole number that begins with 1 and ends in one or more zeros. The numbers 10, 100, 1000, 10,000, and so on are powers of 10.

To multiply a whole number by a power of 10:

1. Count the number of zeros in the power of 10.
2. Attach that number of zeros to the right side of the other whole number to obtain the answer.

Example 5 Multiply 358 by each number.

(a) 10 **(b)** 100 **(c)** 1000 **(d)** 100,000

Solution

(a) $358 \times 10 = 3580$ (one zero)

(b) $358 \times 100 = 35{,}800$ (two zeros)

(c) $358 \times 1000 = 358{,}000$ (three zeros)

(d) $358 \times 100{,}000 = 35{,}800{,}000$ (five zeros)