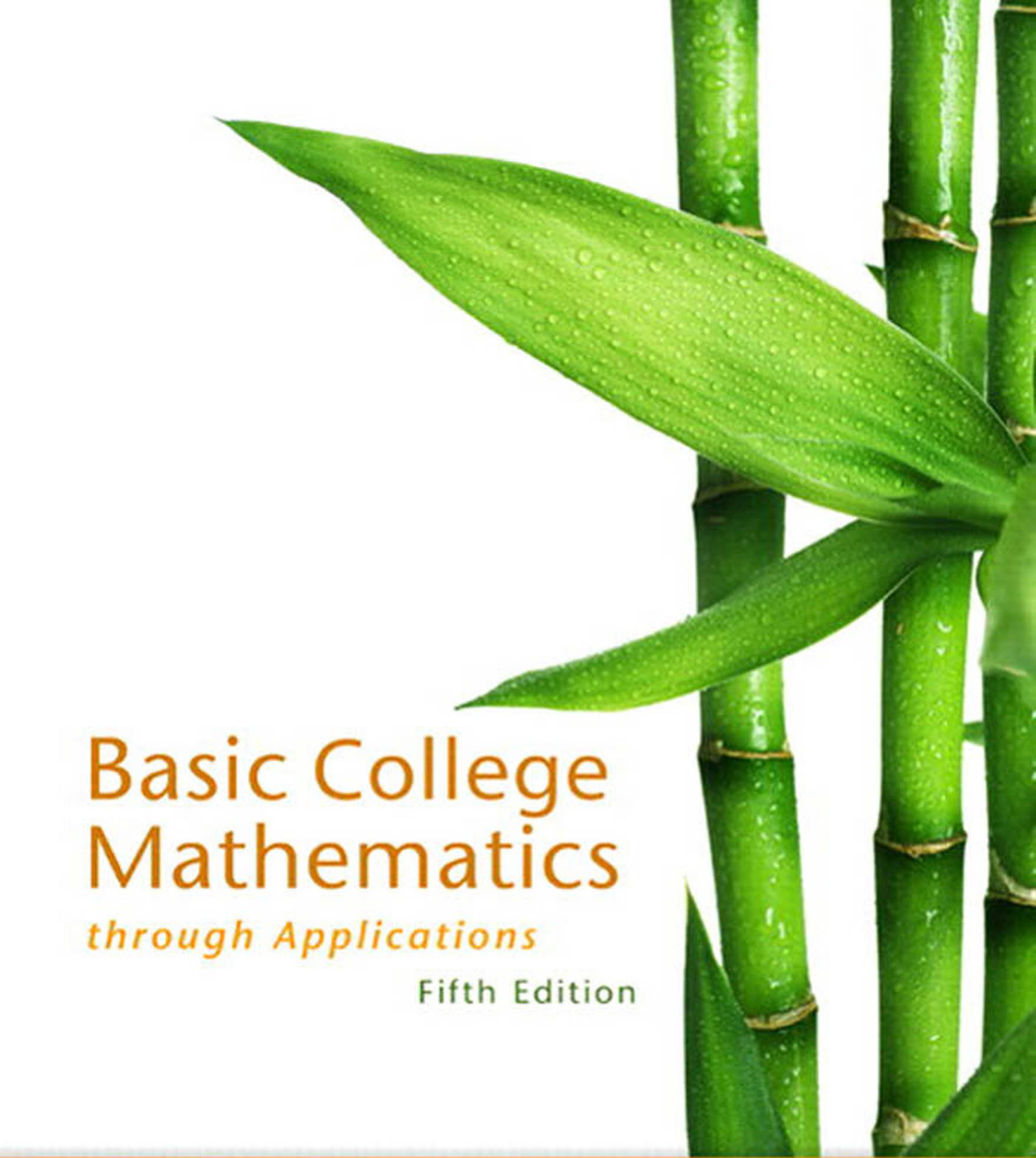

Basic College Mathematics

through Applications

Fifth Edition

GEOFFREY AKST SADIE BRAGG

Basic College Mathematics

through Applications

Fifth Edition

GEOFFREY AKST • SADIE BRAGG
Borough of Manhattan Community College, The City University of New York

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Contents

Preface

FROM THE AUTHORS

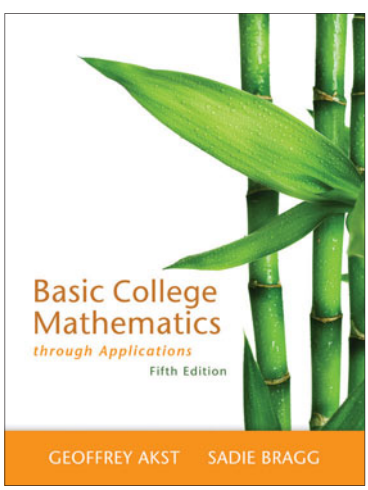
Our goal in writing *Basic College Mathematics through Applications* was to create a text that would help students progress and succeed in their college developmental math course. Throughout, we emphasize an applied approach, which has two advantages. First of all, it can help students prepare to meet their future mathematical demands—across disciplines, in subsequent coursework, in everyday life, and on the job. Secondly, this approach can be motivating, convincing students that mathematics is worth learning and more than just a school subject.

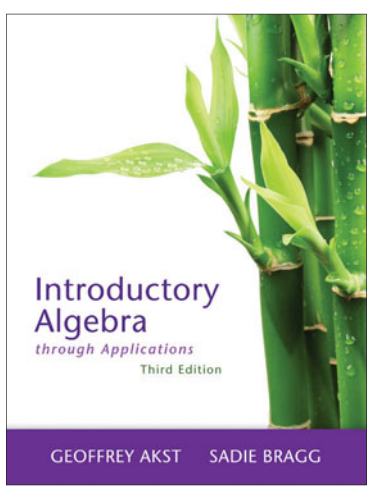
We have attempted to make the text readable, with understandable explanations and exercises for honing skills. We have also put together a set of easy-to-grasp features, consistent across sections and chapters.

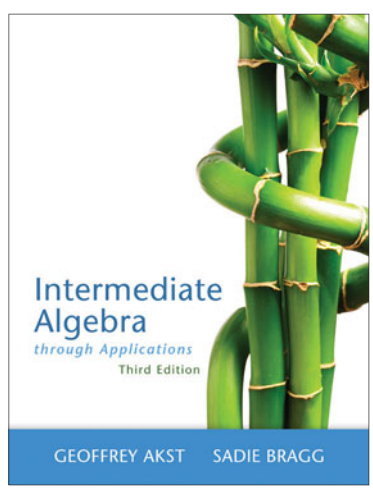
In an effort to address many of the issues raised by national professional organizations, including AMATYC, NCTM, and NADE, we have been careful to stress connections to other disciplines; to incorporate the appropriate use of technology; to integrate quantitative reasoning skills; to include problem sets that facilitate student writing, critical thinking, and collaborative activities; and to emphasize real world data in examples and exercises. We have also introduced algebra early in the text to show an algebraic solution to a broad range of problems in successive chapters.

Above all, we have tried to develop a flexible text that can meet the needs of students in both traditional and redesigned developmental courses.

This text is part of the *through Applications* series that includes the following:







WHAT'S NEW IN THE FIFTH EDITION?

Say Why Exercises New fill-in-the-blank problems, located at the beginning of each chapter review, providing practice in reasoning and communicating mathematical ideas (see page 243).

Updated Content Adjusted content reflecting changing real-world needs. For instance, updates extend the place value concept from billions to trillions and the discussion of units to include the prefixes "mega-," "giga-," and "micro-," which are increasingly common in technology and medicine (see page 446).

Updated and Expanded Section Exercise Sets Additional practice in mastering skills (see pages 359–361).

Chapter Openers Extended real-world applications at the beginning of each chapter to motivate student interest and demonstrate how mathematics is used (see page 275).

Lengthening of Cumulative Review Exercise Sets Twice as many review exercises in response to user demand (see page 247).

Greater Emphasis on Learning Objectives End-of-section exercises closely aligned with the learning objectives in order to encourage and facilitate review (see pages 3 and 9–11).

More Examples and Exercises Based on Real Data Additional and more varied applied problems that are useful, realistic, and authentic (see page 8).

Parallel Paired Exercises Odd/even pairs of problems that more closely reflect the same learning objective (see page 298).

Easy-to-Locate Features Color borders added for back-of-book answer, glossary, and index pages.

Highlighting of Quantitative Literacy Skills Additional exercises that provide practice in number sense, proportional reasoning, and the interpretation of tables and graphs (see pages 28–30).

Increased Attention to Photos and Graphics Carefully selected photos to make problems seem more realistic, and relevant graphics to better meet the needs of visual learners (see pages 203 and 283).

Newly Expanded and Robust MyMathLab Coverage! One of *every* problem type is now assignable in MyMathLab.

Now Two MyMathLab Course Options

1. **Standard MyMathLab** allows you to build *your* course *your* way, offering maximum flexibility and complete control over all aspects of assignment creation. Starting with a clean slate lets you choose the exact quantity and type of problems you want to include for your students. You can also select from prebuilt assignments to give you a starting point.
2. **Ready-to-Go MyMathLab** comes with assignments prebuilt and preassigned, reducing start-up time. You can always edit individual assignments, as needed, through the semester.

KEY FEATURES

Math Study Skills Foldout A full-color foldout with tips on organization, test preparation, time management, and more (see inside front cover).

Pretests and Posttests Chapter tests, which are particularly useful in a self-paced, lab, or digital environment (see page 214).

Section Objectives Clearly stated learning objectives at the beginning of each section to identify topics to be covered (see page 3).

Side-by-Side Example/Practice Format Distinctive side-by-side format that pairs each example with a corresponding practice exercise and gets students actively involved from the start (see page 175).

Tips Helpful suggestions and cautions for avoiding mistakes (see page 83).

Journal Entries Writing assignments in response to probing questions interspersed throughout the text (see page 233).

Calculator Inserts Optional calculator and computer software instruction to solve section problems (see page 23).

Cultural Notes Glimpses of how mathematics has evolved across cultures and throughout history (see page 332).

For Extra Help Boxes at the beginning of every section's exercise set that direct students to helpful resources that will aid in their study of the material (see page 80).

Mathematically Speaking Exercises Vocabulary exercises in each section to help students understand and use standard mathematical terminology (see page 90).

Mixed Practice Exercises Problems in synthesizing section material (see page 63).

Application Exercises End-of-section problems to apply the topic at hand in a wide range of contexts (see pages 106–107).

Mindstretcher Exercises Nonstandard section problems in critical thinking, mathematical reasoning, pattern recognition, historical connections, writing, and group work to deepen understanding and provide enrichment (see page 108).

Key Concepts and Skills Summary With a focus on descriptions and examples, the main points of the chapter organized into a practical and comprehensive chart (see pages 145–147).

Chapter Review Exercises Problems for reviewing chapter content, arranged by section (see pages 243–244).

Chapter Mixed Application Exercises Practice in applying topics across the chapter (see page 245).

Cumulative Review Exercises Problems to maintain and build on the mathematical content covered in previous chapters (see pages 271–272).

Scientific Notation Appendix A brief appendix of particular value to students in the sciences.

U.S. and Metric Unit Tables Located opposite the inside back cover for quick reference.

Geometric Formulas A reference on the inside back cover of the text displaying standard formulas for perimeter, circumference, area, and volume.

Coherent Development Texts with consistent content and style across the developmental math curriculum.

WHAT SUPPLEMENTS ARE AVAILABLE?

For a complete list of the supplements and study aids that accompany *Basic College Mathematics through Applications*, Fifth Edition, see pp. xi.

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Sadie Bragg

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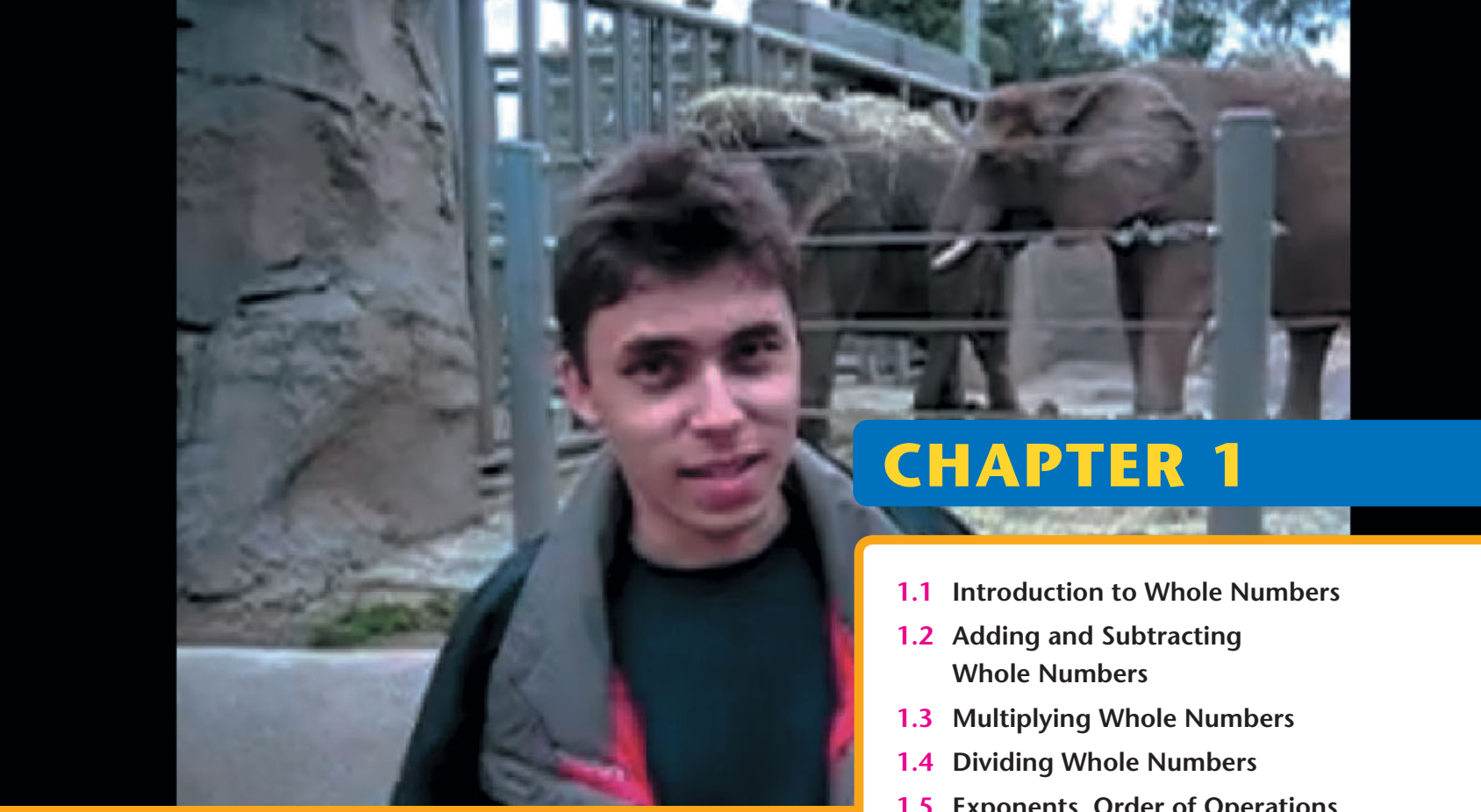


CHAPTER 1

Whole Numbers

Whole Numbers and YouTube

YouTube is a website where users can upload and view videos. These include movie clips, TV clips, music videos, and amateur content. This site made it feasible for anyone with an Internet connection to publish a video that could be seen by a worldwide audience within a few minutes.

In February 2005, the company was set up in a garage by several work colleagues. The first video posted on YouTube was *Me at the Zoo*, in which founder Jawed Karim is seen at the San Diego Zoo.

The usage of the site grew at an astonishing rate. By July 2006, more than 65,000 new videos were being uploaded every day, with about 10,000,000 visitors and 100,000,000 video views per day. Barely a year after its founding, the company was bought by Google for approximately $1,650,000,000.

YouTube has made sharing online video such an important part of Internet culture that it's been said "if it's not on YouTube, it's like it never happened."

(*Sources:* telegraph.co.uk, comscore.com, wikipedia.org, and cleancutmedia.com)

CHAPTER 1 PRETEST

To see if you have already mastered the topics in this chapter, take this test.

1. Insert commas as needed in the number 2 0 5 0 0 7. Then write the number in words.

2. Write the number one million, two hundred thirty-five thousand in standard form.

3. What place does the digit 8 occupy in 805,674?

4. Round 8,143 to the nearest hundred.

5. Add: $38 + 903 + 7{,}285$

6. Subtract 286 from 5,000.

7. Subtract: $734 - 549$

8. Find the product of 809 and 36.

9. Find the quotient: $27\overline{)7{,}020}$

10. Divide: $13{,}558 \div 44$

11. Write $2 \cdot 2 \cdot 2$, using exponents.

12. Evaluate: 6^2

Simplify.

13. $26 - 7 \cdot 3$

14. $3 + 2^3 \cdot (8 - 3)$

Solve and check.

15. The mathematician Benjamin Banneker was born in 1731 and died in 1806. About how old was he when he died? (*Source: The New Encyclopedia Britannica*)

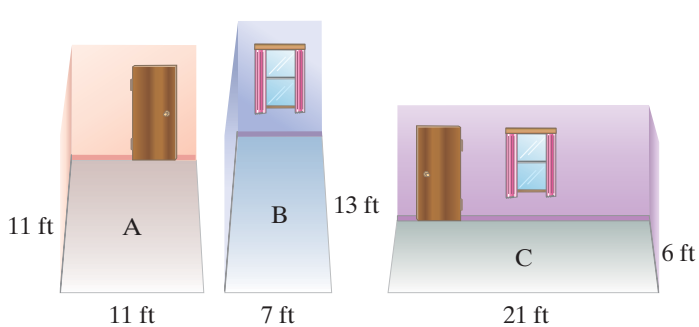
16. At a certain college, students pay $105 for each college credit. If a student takes 9 credits and pays with a $1,000 voucher, how much change will he receive?

17. Phil Mickelson had scores of 67, 71, 67, and 67 for his four rounds at the 2010 Masters Tournament. What was his average score for a round of golf?

18. The Epson PictureMate Show Compact Photo Printer can print a 4-inch by 6-inch photo in 37 seconds, and the Epson Artisan 810 All-in-One Printer can print the same size photo in 10 seconds. How much longer would it take the Epson PictureMate Show to print twelve 4-inch by 6-inch photos? (*Source:* epson.com)

19. An insurance company offers an installment plan for paying auto insurance premiums. For a $540 policy, the plan requires a down payment of $81. The balance is paid in nine equal installments of $55, which includes a service charge. How much money would be saved by paying for this policy without using the installment plan?

20. Which of the rooms pictured has the largest area? (feet = ft)



• Check your answers on page A-1.

1.1 Introduction to Whole Numbers

OBJECTIVES

- **A** To read or write whole numbers
- **B** To write whole numbers in expanded form
- **C** To round whole numbers
- **D** To solve applied problems involving reading, writing, or rounding whole numbers

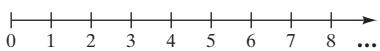
What the Whole Numbers Are and Why They Are Important

We use whole numbers for counting, whether it is the number of *e*'s on this page, the number of stars in the sky, or the number of runs, hits, and errors in a baseball game.

The whole numbers are 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, ... An important property of whole numbers is that there is always a next whole number. This property means that they go on without end, as the three dots above indicate.

Every whole number is either *even* or *odd*. The even whole numbers are 0, 2, 4, 6, 8, 10, 12, ... The odd whole numbers are 1, 3, 5, 7, 9, 11, 13, ...

We can represent the whole numbers on a number line. Similar to a ruler, the number line starts with 0 and extends without end to the right, as the arrow indicates.



Reading and Writing Whole Numbers

Generally speaking, we *read* whole numbers in words, but we use the **digits** 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9 to *write* them. For instance, we read the whole number *fifty-one* but write it *51*, which we call **standard form**.

Each of the digits in a whole number in standard form has a **place value**. Our place value system is very important because it underlies both the way we write and the way we compute with numbers.

The following chart shows the place values in whole numbers up to 15 digits long. For instance, in the number 1,234,056 the digit 2 occupies the hundred thousands place. Study the place values in the chart now.

TRILLIONS			BILLIONS			MILLIONS			THOUSANDS			ONES		
Hundred trillions	Ten trillions	Trillions	Hundred billions	Ten billions	Billions	Hundred millions	Ten millions	Millions	Hundred thousands	Ten thousands	Thousands	Hundreds	Tens	Ones
								1	2	3	4	0	5	6
					8	1	6	8	9	3	1	0	4	7

← Period
← Place value

TIP We read whole numbers from left to right, but it is easier in the place value chart to learn the names of the places *from right to left*.

When we write a large whole number in standard form, we insert *commas* to separate its digits into groups of three, called **periods**. For instance, the number 8,168,931,047 has four periods: *ones, thousands, millions*, and *billions*.

EXAMPLE 1

In each number, identify the place that the digit 7 occupies.

a. 207 **b.** 7,654,000 **c.** 5,700,000,001

Solution

a. The ones place

b. The millions place

c. The hundred millions place

PRACTICE 1

What place does the digit 8 occupy in each number?

a. 278,056

b. 803,746

c. 3,080,700,059

The following rule provides a shortcut for *reading a whole number*:

To Read a Whole Number

Working from left to right,

- read the number in each period and then
- name the period in place of the comma.

For instance, 1,234,056 is read "one million, two hundred thirty-four thousand, fifty-six." Note that the ones period is not read.

EXAMPLE 2

How do you read the number 422,000,085?

Solution Beginning at the left in the millions period, we read this number as "four hundred twenty-two million, eighty-five." Note that because there are all zeros in the thousands period, we do not read "thousands."

PRACTICE 2

Write 8,000,376,052 in words.

EXAMPLE 3

The display on a calculator shows the answer 3578002105. Insert commas in this answer and then read it.

Solution The number with commas is 3,578,002,105. It is read "three billion, five hundred seventy-eight million, two thousand, one hundred five."

PRACTICE 3

A company is worth $7372050. After inserting commas, read this amount.

Until now, we have discussed how to *read* whole numbers in standard form. Now, let's turn to the question of how they are *written* in standard form. We simply reverse the process just described. For instance, the number eight billion, one hundred sixty-eight million, nine hundred thirty-one thousand, forty-seven in standard form is 8,168,931,047. Here, we use the 0 as a **placeholder** in the hundreds place because there are no hundreds.

To Write a Whole Number

Working from left to right,

- write the number named in each period and
- replace each period name with a comma.

When writing large whole numbers in standard form, we must remember that the number of commas is always one less than the number of periods. For instance, the number one million, two hundred thirty-four thousand, fifty-six—1,234,056—has three periods and two commas. Similarly, the number 8,168,931,047 has four periods and three commas.

EXAMPLE 4

Write the number eight billion, seven in standard form.

Solution This number involves billions, so there are four periods—billions, millions, thousands, and ones—and three commas. Writing the number named in each period and replacing each period name with a comma, we get 8,000,000,007. Note that we write three 0's when no number is named in a period.

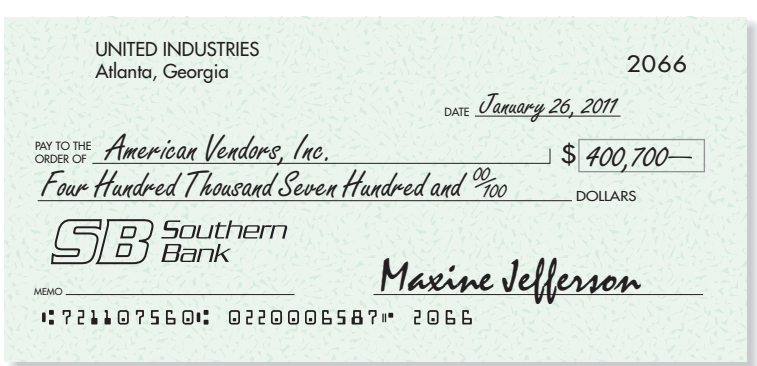
PRACTICE 4

Use digits and commas to write the amount ninety-five million, three dollars.

EXAMPLE 5

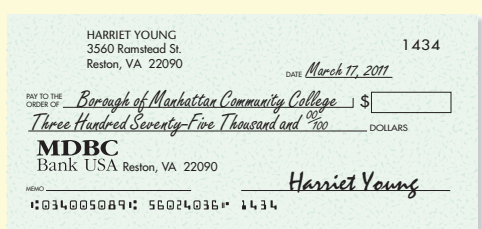
The treasurer of a company writes a check in the amount of four hundred thousand seven hundred dollars. Using digits, how would she write this amount on the check?

Solution This quantity is written with one comma, because its largest period is thousands. So the treasurer writes $400,700, as shown on the check below.


UNITED INDUSTRIES
Atlanta, Georgia
2066
DATE January 26, 2011
PAY TO THE ORDER OF American Vendors, Inc. $ 400,700—
Four Hundred Thousand Seven Hundred and 00/100 DOLLARS
SB Southern Bank
MEMO
Maxine Jefferson
⑆072107560⑆ 022000658?⑈ 2066

PRACTICE 5

A rich alumna donates three hundred seventy-five thousand dollars to her college's scholarship fund.


HARRIET YOUNG
3560 Ramstead St.
Reston, VA 22090
1434
DATE March 17, 2011
PAY TO THE ORDER OF Borough of Manhattan Community College $
Three Hundred Seventy-Five Thousand and 00/100 DOLLARS
MDBC
Bank USA Reston, VA 22090
MEMO
Harriet Young
⑆034005089⑆ 560240361⑈ 1434

Using digits, how would she write this amount on the check?

When writing checks, we write the amount in both digits and words. Why do we do this?

Writing Whole Numbers in Expanded Form

We have just described how to write whole numbers in standard form. Now, let's turn to how we write these numbers in **expanded form**.

Let's consider the whole number 4,025 and examine the place value of its digits.

$$4{,}025 = 4 \text{ thousands} + 0 \text{ hundreds} + 2 \text{ tens} + 5 \text{ ones}$$

This last expression is called the expanded form of the number, and it can be written as follows

$$4{,}000 + 0 + 20 + 5, \quad \text{or} \quad 4{,}000 + 20 + 5$$

The expanded form of a number spells out its value in terms of place value, helping us understand what the number really means. For instance, think of the numbers 92 and 29. By representing them in *expanded* form, can you explain why they differ in value even though their *standard* form consists of the same digits?

EXAMPLE 6

Write in expanded form:

a. 906 **b.** 3,203,000

Solution

a. The 6 is in the ones place, the 0 is in the tens place, and the 9 is in the hundreds place.

ONES		
Hundreds	**Tens**	**Ones**
9	0	6

So 906 is 9 hundreds + 0 tens + 6 ones = 900 + 0 + 6, or 900 + 6 in expanded form.

b. Using the place value chart, we see that

$$\begin{aligned} 3{,}203{,}000 &= 3 \text{ millions} + 2 \text{ hundred thousands} + 3 \text{ thousands} \\ &= 3{,}000{,}000 + 200{,}000 + 3{,}000. \end{aligned}$$

PRACTICE 6

Express in expanded form:

a. 27,013

b. 1,270,093

Rounding Whole Numbers

Most people equate mathematics with precision, but some problems require sacrificing precision for simplicity. In this case, we use the technique called **rounding** to approximate the exact answer with a number that ends in a given number of zeros. Rounded numbers have special advantages: They seem clearer to us than other numbers, and they make computation easier—especially when we are trying to compute in our heads.

Of these two headlines, which do you prefer? Why?

Study the following chart to see the connection between place value and rounding.

Rounding to the nearest	Means that the rounded number ends in at least
10	One 0
100	Two 0's
1,000	Three 0's
10,000	Four 0's
100,000	Five 0's
1,000,000	Six 0's

Note in the chart that the place value tells us how many 0's the rounded number must have at the end. Having more 0's than indicated is possible. Can you think of an example?

When rounding, we use an underlined digit to indicate the place to which we are rounding. Now, let's consider the following rule for rounding whole numbers:

To Round a Whole Number

- Underline the place to which you are rounding.
- The digit to the right of the underlined digit is called the *critical digit.* Look at the critical digit—if it is 5 or more, add 1 to the underlined digit; if it is less than 5, leave the underlined digit unchanged.
- Replace all the digits to the right of the underlined digit with zeros.

EXAMPLE 7

Round 79,630 to

a. the nearest thousand

b. the nearest hundred

Solution

a. $79{,}630 = 7\underline{9},630$ ← Underline the digit in the thousands place.

$= 7\underline{9},630$ ← The critical digit 6 is greater than 5; add 1 to the underlined digit.

$\approx 80{,}000$ ← Change the digits to the right of the underlined digit to 0's.

↑ This symbol means "is approximately equal to."

Note that adding 1 to the underlined digit gave us 10. As a result we regroup, that is, write 0, carry 1 to the next column, and change the 7 to 8.

b. First, we underline the 6 because that digit occupies the hundreds place: $79{,}\underline{6}30$. The critical digit is **3**: $79{,}\underline{6}\mathbf{3}0$. Since 3 is less than 5, we leave the underlined digit unchanged. Then, we replace all digits to the right with 0's, getting 79,600. We write $79{,}630 \approx 79{,}600$, meaning that 79,630 when rounded to the nearest hundred is 79,600.

PRACTICE 7

Round 51,760 to

a. the nearest thousand

b. the nearest ten thousand

For Example 7a, consider this number line.

The number line shows that 79,630 lies between 79,000 and 80,000 and that it is closer to 80,000, as the rule indicates.

EXAMPLE 8

In an anatomy and physiology class, a student learned that the adult human skeleton contains 206 bones. How many bones is this to the nearest hundred bones?

Solution We first write 206. The critical digit 0 is less than 5, so we do *not* add 1 to the underlined digit. However, we do change both the digits to the right of the 2 to 0's. So $206 \approx 200$, and there are approximately 200 bones in the human body.

PRACTICE 8

Based on current population data, the U.S. Bureau of the Census projects that the U.S. resident population will be 419,845,000 in the year 2050. What is the projected population to the nearest million?

EXAMPLE 9

The following table lists five of the highest-grossing films of all time and the amount of money they took in.

Film	Year	World Total (in U.S. dollars)
Titanic	1997	$1,835,300,000
The Lord of the Rings: The Return of the King	2003	$1,129,219,252
Pirates of the Caribbean: Dead Man's Chest	2006	$1,060,332,628
The Dark Knight	2008	$1,001,921,825
Avatar	2009	$2,690,408,054

(*Source:* imdb.com)

a. Write in words the amount of money taken in by the film with the largest world total.

b. Round to the nearest ten million dollars the world total for *Titanic*.

Solution

a. *Avatar* has the largest world total. This total is read "two billion, six hundred ninety million, four hundred eight thousand, fifty-four dollars."

b. The world total for *Titanic* is $1,835,300,000. To round, we underline the digit in the ten millions place: 1,8$\underline{3}$5,300,000. Since the critical digit is 5, we add 1 to the underlined digit, and change the digits to the right to 0's. So the rounded total is $1,840,000,000.

PRACTICE 9

This chart gives the number of U.S. postsecondary teachers in the year 2008 as well as the projected number of postsecondary teachers for the year 2018.

Year	Number of Postsecondary Teachers
2008	1,699,200
2018	1,956,100

(*Source:* bls.gov)

a. Write in words the number of postsecondary teachers in the year 2008.

b. What is the number of projected postsecondary teachers in the year 2018 rounded to the nearest ten thousand?

1.1 Exercises

FOR EXTRA HELP MyMathLab MathXL PRACTICE WATCH READ REVIEW

Mathematically Speaking

Fill in each blank with the most appropriate term or phrase from the given list.

calculated	rounded	periods	odd
even	digits	whole numbers	standard form
placeholder	place value	expanded form	

1. The _____ are 0, 1, 2, 3, 4, 5, ...

2. The numbers 0, 2, 4, 6, 8, 10, . . . are _____.

3. The numbers 1, 3, 5, 7, 9, . . . are _____.

4. The whole numbers are written with the _____ 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9.

5. The number thirty-seven, when written as 37, is said to be in _____.

6. In the number 528, the _____ of the 5 is hundreds.

7. In the number 206, the 0 is used as a _____ in the tens place.

8. Commas separate the digits in a large whole number into groups of three called _____.

9. When the number 973 is written as 9 hundreds + 7 tens + 3 ones, it is said to be in _____.

10. The number 545 _____ to the nearest hundred is 500.

A *Underline the digit that occupies the given place.*

11. 4,867 Thousands place

12. 9,752 Thousands place

13. 316 Tens place

14. 728 Tens place

15. 28,461,013 Millions place

16. 73,762,800 Millions place

Identify the place occupied by the underlined digit.

17. 691,400

18. 72,109

19. 7,380

20. 351

21. 8,450,000,000

22. 35,832,775

Insert commas as needed, and then write the number in words.

23. 4 8 7 5 0 0

24. 5 2 8 0 5 0

25. 2 3 5 0 0 0 0

26. 1 3 5 0 1 3 2

27. 9 7 5 1 3 5 0 0 0

28. 4 2 1 0 0 0 1 3 2

29. 2 0 0 0 0 0 0 3 5 2

30. 4 1 0 0 0 0 0 0 0 7

31. 1 0 0 0 0 0 0 0 0 0

32. 3 7 9 0 5 2 0 0 0