

Developmental Math for College Students

**Prealgebra, Introductory Algebra,
and Intermediate Algebra**

Robert Blitzer

Miami Dade College

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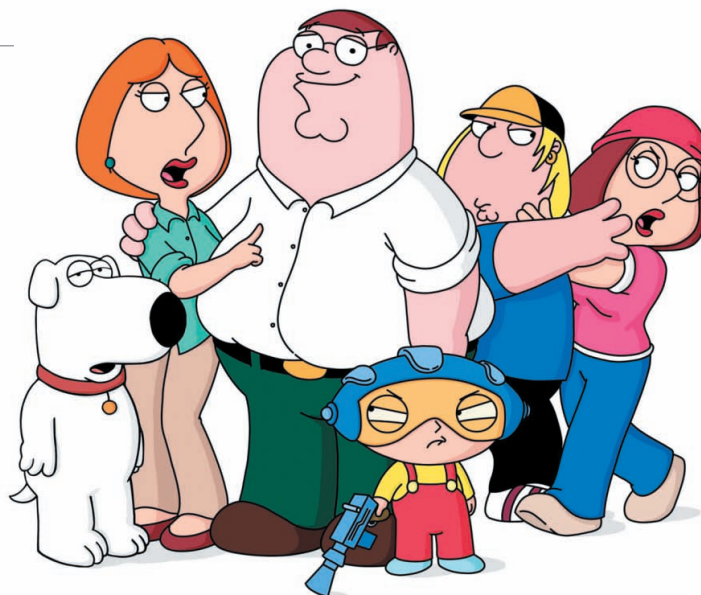
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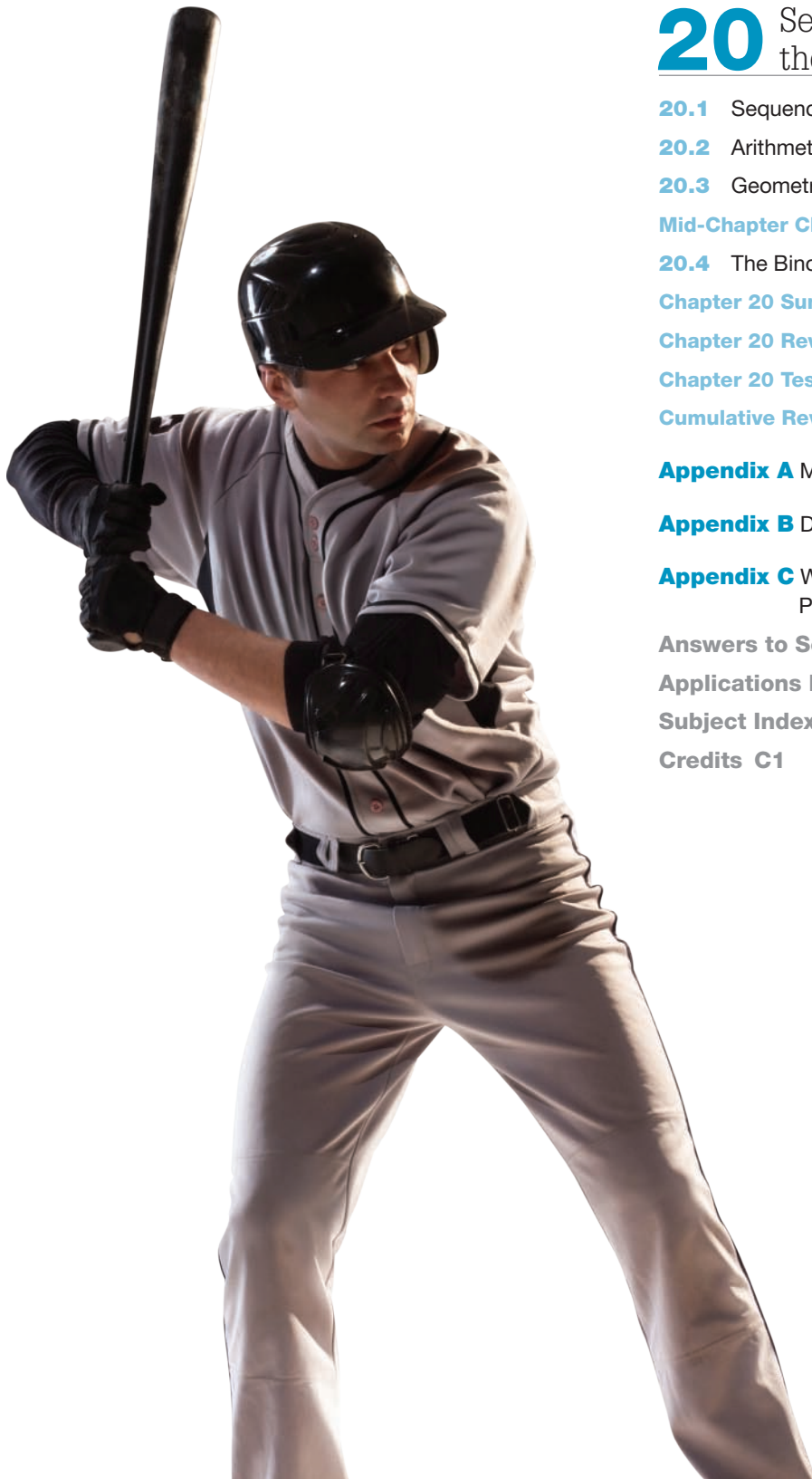
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Preface

Developmental Math for College Students provides comprehensive, in-depth coverage of the topics in a course combining the study of prealgebra (Chapter 1 – Chapter 7), introductory algebra (Chapter 8 – Chapter 13), and intermediate algebra (Chapter 14 – Chapter 20). The book is written for college students who have no previous experience in algebra and for those who need a review of arithmetic concepts before moving on to algebra. I wrote the book to help diverse students, with different backgrounds and career plans, to succeed in a course sequence covering prealgebra, introductory algebra, and intermediate algebra. *Developmental Math for College Students* has two primary goals:

1. To help students acquire a solid foundation in the basic skills and concepts of arithmetic, introductory algebra, and intermediate algebra for success in future STEM and non-STEM directed math courses, without the repetition of topics in three separate texts.
2. To show students how arithmetic and algebra can model and solve authentic real-world problems.

One major obstacle in the way of achieving these goals is the fact that very few students actually read their textbook. This has been a regular source of frustration for me and for my colleagues in the classroom. Anecdotal evidence gathered over years highlights two basic reasons students give when asked why they do not take advantage of their textbook:

- “I’ll never use this information.”
- “I can’t follow the explanations.”

I’ve written every page of *Developmental Math* with the intent of eliminating these two objections. The ideas and tools I’ve used to do so are described in the features that follow. These features and their benefits are highlighted for the student in “A Brief Guide to Getting the Most from This Book,” which appears inside the front cover.

Pedagogical Features

- **Learning Objectives.** Learning objectives, framed in the context of a student question (What am I supposed to learn?), are clearly stated at the beginning of each section. These objectives help students recognize and focus on the section’s most important ideas. The objectives are restated in the margin at their point of use.
- **Chapter-Opening and Section-Opening Scenarios.** Every chapter and every section open with a scenario presenting a unique application of mathematics in students’ lives outside the classroom. These scenarios are revisited in the course of the chapter or section in an example, discussion, or exercise.

- **Innovative Applications.** A wide variety of interesting applications, supported by up-to-date, real-world data, are included in every section.
- **Detailed Worked-Out Examples.** Each example is titled, making the purpose of the example clear. Examples are clearly written and provide students with detailed step-by-step solutions. No steps are omitted and each step is thoroughly explained to the right of the mathematics.
- **Explanatory Voice Balloons.** Voice balloons are used in a variety of ways to demystify mathematics. They translate arithmetic and algebraic ideas into everyday English, help clarify problem-solving procedures, present alternative ways of understanding concepts, and connect problem solving to concepts students have already learned.
- **Check Point Examples.** Each example is followed by a similar matched problem, called a Check Point, offering students the opportunity to test their understanding of the example by working a similar exercise. The answers to the Check Points are provided in the answer section.
- **Concept and Vocabulary Checks.** This feature offers short-answer exercises, mainly fill-in-the-blank and true/false items, that assess students' understanding of the definitions and concepts presented in each section. The Concept and Vocabulary Checks appear as separate features preceding the Exercise Sets.
- **Extensive and Varied Exercise Sets.** An abundant collection of exercises is included in an Exercise Set at the end of each section. Exercises are organized within eight category types: Practice Exercises, Practice Plus Exercises, Application Exercises, Explaining the Concepts, Critical Thinking Exercises, Technology Exercises, Review Exercises, and Preview Exercises. This format makes it easy to create well-rounded homework assignments. The order of the Practice Exercises is exactly the same as the order of the section's worked examples. This parallel order enables students to refer to the titled examples and their detailed explanations to achieve success working the Practice Exercises.
- **Practice Plus Problems.** This category of exercises contains more challenging practice problems that often require students to combine several skills or concepts. With an average of ten Practice Plus problems per Exercise Set, instructors are provided with the option of creating assignments that take Practice Exercises to a more challenging level.
- **Brief Reviews.** The Brief Review boxes, appearing primarily in the prealgebra chapters (Chapter 1 – Chapter 7), summarize mathematical skills that students have learned previously, but which many students still need to review. This feature appears whenever a particular skill is first needed and eliminates the need for you to reteach that skill.
- **Early Introduction of Algebraic Concepts.** Algebra is introduced in Chapter 1. Algebraic concepts are integrated with traditional arithmetic concepts throughout the prealgebra portion of the text, laying the groundwork for the introductory algebra topics that begin with Chapter 8.
- **Extensive Application to Geometric Problem Solving.** Many students enter a developmental math course with little or no knowledge of Euclidean geometry. Consequently, this book teaches (rather than reviews) geometric concepts that are important to a student's understanding of arithmetic and algebra. Although Chapter 6 in the prealgebra portion of the text is devoted exclusively to geometry, literacy in geometry is developed throughout the prealgebra, introductory algebra, and intermediate algebra sections of the book by the use of extensive applications involving geometric problem solving.
- **Early Graphing.** Prealgebra chapters connect traditional arithmetic topics to data displayed by bar, line, and circle graphs. The rectangular coordinate system is introduced in Chapter 9, the second chapter in the introductory algebra portion of the book. Graphs appear in nearly every section and Exercise Set throughout the text. Examples and exercises use graphs to explore relationships between data and to provide ways of visualizing a problem's solution.

- **Early Functions in Intermediate Algebra.** Functions are introduced in Chapter 14, the chapter that opens the intermediate algebra section of the text. Because functions are the core of intermediate algebra, students are repeatedly shown how functions relate to equations and graphs in Chapters 14 through 20.
- **Mid-Chapter Check Points.** At approximately the midway point in each chapter, an integrated set of Review Exercises allows students to review and assimilate the skills and concepts they learned separately over several sections.
- **Check Points for Prealgebra and Introductory Algebra.** Following Chapters 1 through 7 is an integrated set of prealgebra Review Exercises that allows students to determine if they are prepared for introductory algebra. Following Chapters 8 through 13 is an integrated set of introductory algebra Review Exercises for students to determine if they are prepared for intermediate algebra.
- **Great Question!** This feature presents a variety of study tips in the context of students' questions. Answers to questions offer suggestions for problem solving, point out common errors to avoid, and provide informal hints and suggestions. As a secondary benefit, this feature should help students not to feel anxious or threatened when asking questions in class.
- **Achieving Success.** The Achieving Success boxes at the end of many sections offer strategies for persistence and success in college mathematics courses.
- **Thorough, Yet Optional, Technology.** Although the use of graphing utilities is optional, they are utilized in the book's introductory and intermediate algebra chapters in Using Technology boxes to enable students to visualize and gain numerical insight into algebraic concepts. The use of graphing utilities is also reinforced in the Technology Exercises appearing in the Exercise Sets for those who want this option. With the book's early introduction to graphing in introductory algebra, students can look at the calculator screens in the Using Technology boxes and gain an increased understanding of an example's solution even if they are not using a graphing utility in the course.
- **Chapter Review Grids.** Each chapter contains a review chart that summarizes the definitions and concepts in every section of the chapter. Examples that illustrate these key concepts are also included in the chart.
- **End-of-Chapter Materials.** A comprehensive collection of Review Exercises for each of the chapter's sections follows the review grid. This is followed by a Chapter Test that enables students to test their understanding of the material covered in the chapter. Beginning with Chapter 3, each chapter concludes with a comprehensive collection of mixed Cumulative Review Exercises.
- **Blitzer Bonuses.** These enrichment essays provide historical, interdisciplinary, and otherwise interesting connections to the arithmetic and algebra under study, showing students that math is an interesting and dynamic discipline.
- **Discovery.** Discover for Yourself boxes, found throughout the text, encourage students to further explore arithmetic and algebraic concepts. These explorations are optional and their omission does not interfere with the continuity of the topic under consideration.

I hope that my passion for teaching, as well as my respect for the diversity of students I have taught and learned from over the years, is apparent throughout this book. By connecting arithmetic and algebra to the whole spectrum of learning, it is my intent to show students that their world is profoundly mathematical, and indeed, π is in the sky.

Robert Blitzer

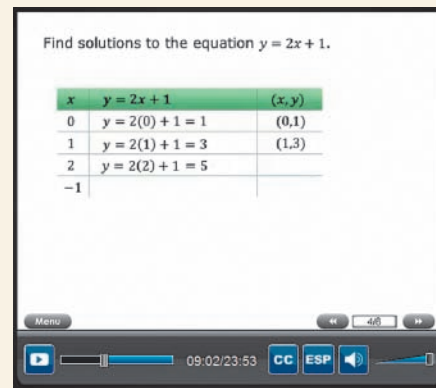
Resources for Success

MyMathLab for the Blitzer Developmental Algebra Series

MyMathLab is available to accompany Pearson’s market-leading text offerings. This text’s flavor and approach are tightly integrated throughout the accompanying MyMathLab course, giving students a consistent tone, voice, and teaching method that make learning the material as seamless as possible.

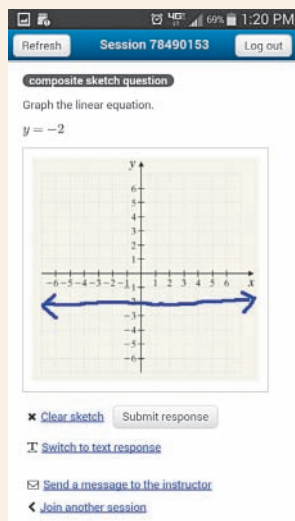
Section Lecture and Chapter Test Prep Videos

An **updated** video program provides a multitude of resources for students. Section Lecture videos walk students through the concepts from every section of the text in a fresh, modern presentation format. Chapter Test Prep videos walk students through the solution of every problem in the text’s Chapter Tests, giving students video resources when they might need it most.



Blitzer Bonus Videos

NEW! Animated videos have been created to mirror the Blitzer Bonus features throughout the textbook. Blitzer Bonus features in the text provide interesting real-world connections to the mathematical topics at hand, conveying Bob Blitzer’s signature style to engage students. These new Blitzer Bonus videos will help students to connect the topics to the world around them in a visual way. Corresponding assignable exercises in MyMathLab are also available, allowing these new videos to be turned into a media assignment to truly ensure that students have understood what they’ve watched.



Learning Catalytics

Integrated into MyMathLab, the Learning Catalytics feature uses students’ devices in the classroom for an engagement, assessment, and classroom intelligence system that gives instructors real-time feedback on student learning. Learning Catalytics contains Pearson-created content for developmental math topics that allows you to take advantage of this exciting technology immediately.

Student Success Modules

These modules are integrated within the MyMathLab course to help students succeed in college courses and prepare for future professions.

Resources for Success

Instructor Resources

Annotated Instructor's Edition

This version of the text contains answers to exercises printed on the same page, with graphing answers in a special Graphing Answer Section at the back of the text.

The following resources can be downloaded from www.pearsonhighered.com or in MyMathLab.

PowerPoint® Lecture Slides

Fully editable slides correlated with the textbook include definitions, key concepts, and examples for use in a lecture setting.

Instructor's Solutions Manual

This manual includes fully worked-out solutions to all text exercises.

Instructor's Resource Manual

This manual includes a Mini-Lecture, Skill Builder, and Additional Exercises for every section of the text. It also includes Chapter Test forms, as well as Cumulative and Final Exams, with answers.

TestGen®

TestGen® (www.pearsoned.com/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.

Student Resources

The following additional resources are available to support student success:

Learning Guide

Organized by learning objectives, the Learning Guide helps students make the most of their textbook and prepare for tests. Now updated to include projects students will have the opportunity to discover and reinforce the concepts in an active learning environment. These projects are ideal for group work in class. The Learning Guide is available in MyMathLab, and available as a printed supplement.

Video Lecture Series

Available in MyMathLab, the video program covers every section in the text, providing students with a video tutor at home, in lab, or on the go. The program includes Section Lecture Videos and Chapter Test Prep videos.

Student Solutions Manual

This manual provides detailed worked-out solutions to odd-numbered section exercises, plus all Check Points, Review/Preview Exercises, Mid-Chapter Check Points, Chapter Reviews, Chapter Tests, and Cumulative Reviews.

Acknowledgments

An enormous benefit of authoring a successful series is the broad-based feedback I receive from students, dedicated users, and reviewers. I would like to express my appreciation to all the reviewers, whose collective insights helped shape the content and direction of this book. In particular, I would like to thank the following people for reviewing *Developmental Math for College Students*.

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- Shannon Schumann, *University of Phoenix*
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- Morteza Shafii-Mousavi, *Indiana University South Bend*
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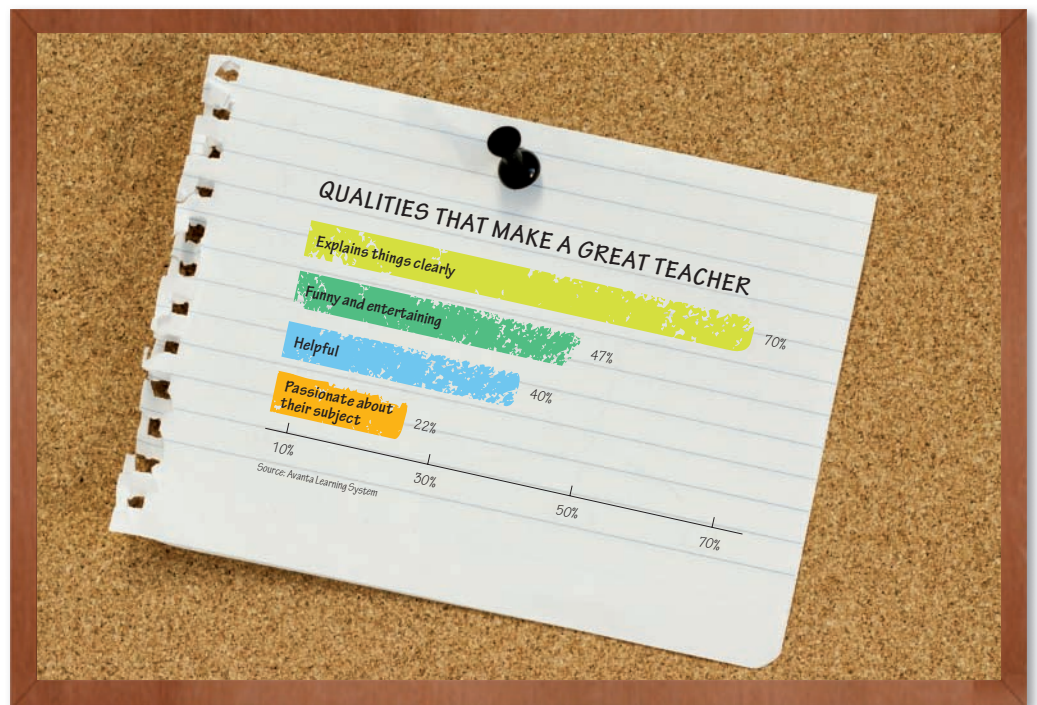
Kathryn Wetzel, *Amarillo College*

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I would like to thank my editors at Pearson, Dawn Giovanniello and Megan Tripp, who guided and coordinated the book from manuscript through production. Thanks to Beth Paquin and Studio Montage for the quirky cover and interior design. Finally, thanks to marketing manager Alicia Frankel for your innovative marketing efforts, and to the entire Pearson sales force, for your confidence and enthusiasm about the book.

To the Student

The bar graph shows some of the qualities that students say make a great teacher.



It was my goal to incorporate each of the qualities that make a great teacher throughout the pages of this book.

Explains Things Clearly

I understand that your primary purpose in reading *Developmental Math for College Students* is to acquire a solid understanding of the required topics in your arithmetic and algebra course. In order to achieve this goal, I've carefully explained each topic. Important definitions and procedures are set off in boxes, and worked-out examples that present solutions in a step-by-step manner appear in every section. Each example is followed by a similar matched problem, called a Check Point, for you to try so that you can actively participate in the learning process as you read the book. (Answers to all Check Points appear in the back of the book.)

Funny/Entertaining

Who says that a developmental math textbook can't be entertaining? From our quirky cover to the photos in the chapter and section openers, prepare to expect the unexpected. I hope some of the book's enrichment essays, called Blitzer Bonuses, will put a smile on your face from time to time.

Helpful

I designed the book's features to help you acquire knowledge of prealgebra, introductory algebra, and intermediate algebra, as well as to show you how arithmetic and algebra can solve authentic problems that apply to your life. These helpful features include:

- ***Explanatory Voice Balloons:*** Voice balloons are used in a variety of ways to make math less intimidating. They translate algebraic language into everyday English, help clarify problem-solving procedures, present alternative ways of understanding concepts, and connect new concepts to concepts you have already learned.
- ***Great Question!:*** The book's Great Question! boxes are based on questions students ask in class. The answers to these questions give suggestions for problem solving, point out common errors to avoid, and provide informal hints and suggestions.
- ***Achieving Success:*** The book's Achieving Success boxes give you helpful strategies for success in learning arithmetic and algebra, as well as suggestions that can be applied for achieving your full academic potential in future college coursework.
- ***Detailed Chapter Review Charts:*** Each chapter contains a review chart that summarizes the definitions and concepts in every section of the chapter. Examples that illustrate these key concepts are also included in the chart. Review these summaries and you'll know the most important material in the chapter!

Passionate about Their Subject

I passionately believe that no other discipline comes close to math in offering a more extensive set of tools for application and development of your mind. I wrote the book in Point Reyes National Seashore, 40 miles north of San Francisco. The park consists of 75,000 acres with miles of pristine surf-washed beaches, forested ridges, and bays bordered by white cliffs. It was my hope to convey the beauty and excitement of mathematics using nature's unspoiled beauty as a source of inspiration and creativity. Enjoy the pages that follow as you empower yourself with the algebra needed to succeed in college, your career, and your life.

*Regards,
Bob*

Robert Blitzer

About the Author

Bob Blitzer is a native of Manhattan and received a Bachelor of Arts degree with dual majors in mathematics and psychology (minor: English literature) from the City College of New York. His unusual combination of academic interests led him toward a Master of Arts in mathematics from the University of Miami and a doctorate in behavioral sciences from Nova University. Bob's love for teaching mathematics was nourished for nearly 30 years at Miami Dade College, where he received numerous teaching awards, including Innovator of the Year from the League for Innovations in the Community College and an endowed chair based on excellence in the classroom. In addition to *Developmental Math for College Students*, Bob has written textbooks covering introductory algebra, intermediate algebra, college algebra, algebra and trigonometry, precalculus, and liberal arts mathematics, all published by Pearson. When not secluded in his Northern California writer's cabin, Bob can be found hiking the beaches and trails of Point Reyes National Seashore, and tending to the chores required by his beloved entourage of horses, chickens, and irritable roosters.



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Whole Numbers and Introduction to Algebra

How would your lifestyle change if a gallon of gas cost \$9.15? Or if the price of a staple such as milk were \$15? That's how much those products would cost if their prices had increased at the same rate as college tuition has increased since 1980.

Tuition and Fees at Four-Year Colleges

	School Year Ending 2000	School Year Ending 2014
Public	\$3362	\$8893
Private	\$15,518	\$31,701

Source: The College Board

If these trends continue, what can we expect for the rest of this decade and beyond? We can answer this question by representing data for tuition and fees at U.S. colleges mathematically. With such representations, called *mathematical models*, we can gain insights on a variety of issues, ranging from college costs to the number of calories needed per day based on lifestyle. In order to use these mathematical models, we need an understanding of the basics of whole numbers and their operations, the focus of our opening chapter.

Here's where you'll find these applications:

- Mathematical models involving college costs are developed in Example 7 and Check Point 7 of Section 1.7, and Exercises 85–86 of Exercise Set 1.7. Applying these models involves computing with whole numbers.
- You'll find the number of calories needed per day based on your lifestyle in Example 11 and Check Point 11 of Section 1.6, and Exercises 69–70 of Exercise Set 1.6.

SECTION

1.1







Basics of Whole Numbers

\$92,233,720,368,547,800



What am I supposed to learn?

After studying this section, you should be able to:

- 1 Identify the place value of a digit in a whole number. 
- 2 Write whole numbers in words and in standard form. 
- 3 Write whole numbers in expanded form. 
- 4 Use inequality symbols to compare whole numbers. 
- 5 Round whole numbers. 
- 6 Read tables and bar graphs involving whole numbers. 

This is the amount a Pennsylvania man found in his PayPal account after receiving an email about his balance, an error the e-commerce site quickly corrected. The accidental quadrillionaire—that’s 17 digits—said he would have used the cash to pay off the national debt and buy the Phillies baseball team, but only if he “could get a great price.”

So, what’s the connection between

92,233,720,368,547,800

and the material in this section? This huge number is an example of a *whole number* in *standard form*. Whole number? Standard form? Read on, as we begin our study of algebra with *whole numbers*, the building blocks of mathematics.

Whole Numbers, Digits, and Place Value

The numbers that we use for counting, 1, 2, 3, 4, 5, 6, 7, and so on, are called **natural numbers**. When we combine 0 with the natural numbers, we obtain the whole numbers.


Whole Numbers

The **whole numbers** are

0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, ...

The smallest whole number is 0.

The three dots mean that the list continues without end. There is no largest whole number. Somewhere in the list is 92,233,720,368,547,800.

- 1 Identify the place value of a digit in a whole number. 

The numbers 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9 are called **digits**, from the Latin word for fingers. Digits are used to write whole numbers.

The position of each digit in a whole number tells us the value of that digit. For example, as of April 2012, the most followed person on Twitter was Lady Gaga with 24,070,362 followers. The two 2s in this whole number represent different values because of their placement. **Figure 1.1** shows a place-value chart for 24,070,362.

Periods																	
Quadrillions			Trillions			Billions		Millions		Thousands		Ones					
Hundred-Quadrillions	Ten-Quadrillions	Quadrillions	Hundred-Trillions	Ten-Trillions	Trillions	Hundred-Billions	Ten-Billions	Billions	Hundred-Millions	Ten-Millions	Millions	Hundred-Thousands	Ten-Thousands	Thousands	Hundreds	Tens	Ones
									2	4	0	7	0	3	6	2	

Figure 1.1 Place-value chart for 24,070,362

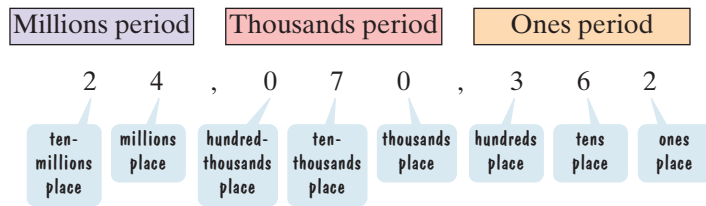
The place-value chart in **Figure 1.1** breaks up a whole number into groups of three, starting from the right. Each group of three digits is called a **period**. Periods in **Figure 1.1** include ones, thousands, millions, billions, trillions, and quadrillions.

A whole number such as 24,070,362 is written in *standard form*.

Standard Form of a Whole Number

A whole number in **standard form** is written using the digits in each period, separating the periods by commas. The commas separate the digits into groups of three, starting from the right.

The voice balloons shown below summarize the place value of each digit in 24,070,362.



EXAMPLE 1 Identifying Place Values

Find the place value of the underlined digit in each whole number.

- a. 2864 b. 3,450,138 c. 469,417 d. 27,000,000.

Solution Let's use an abbreviated place-value chart to identify the place value of each underlined digit.

Millions period	Thousands period	Ones period	Place value of underlined digit
hund. tens ones	hund. tens ones	hund. tens ones	
a.	2	<u>8</u> 6 4	hundreds place
b.	3 , 4 <u>5</u> 0 ,	1 3 8	ten-thousands place
c.	<u>4</u> 6 9 ,	4 1 7	hundred-thousands place
d.	<u>2</u> 7 ,	0 0 0 , 0 0 0	ten-millions place ■


Great Question!

What happened to the comma in 2864? Why didn't you write 2,864?

Whole numbers with four digits may be written with or without a comma. When expressed in standard form, both 2864 and 2,864 are correct. In this text, we will write four-digit numbers without a comma. Whole numbers with five or more digits require commas to separate the digits in each period.

CHECK POINT 1 Find the place value of the underlined digit in each whole number:

- a. 6,493,170
 b. 30,052
 c. 614,023
 d. 25,432,987.

- 2 Write whole numbers in words and in standard form. 

Whole Numbers in Word Form and Standard Form

It is often necessary to express a whole number in words. Here is a procedure that you can use:

Writing the Word Form of a Whole Number Expressed in Standard Form

1. Work from left to right. Write the name of the three-digit number in each period, followed by the name of the period and a comma.
2. Do not write words for periods that contain all zeros (000).
3. Do not write the name of the last period, “ones.”
4. Hyphenate the names for the numbers 21 (twenty-one) through 99 (ninety-nine), except 30, 40, 50, 60, 70, 80, and 90, whenever these numbers appear in any period.

Each day in the world, 18,368,924 people have birthdays. Let’s apply the procedure in the box and write the word name for this whole number. The number has three periods.

Millions period	Thousands period	Ones period
hund. tens ones	hund. tens ones	hund. tens ones
1 8	3 6 8	9 2 4
	,	,
<div style="display: flex; justify-content: space-around; margin-top: 10px;"> <div style="border: 1px solid black; border-radius: 10px; padding: 2px 5px; background-color: #e0f0ff;">eighteen million,</div> <div style="border: 1px solid black; border-radius: 10px; padding: 2px 5px; background-color: #e0f0ff;">three hundred sixty-eight thousand,</div> <div style="border: 1px solid black; border-radius: 10px; padding: 2px 5px; background-color: #e0f0ff;">nine hundred twenty-four</div> </div>		

The word name for 18,368,924 is *eighteen million, three hundred sixty-eight thousand, nine hundred twenty-four*.

Great Question!

Shouldn’t the word name for 924 be nine hundred *and* twenty-four?

No. The word *and* is not used in writing names for whole numbers. In Chapter 4, you will see that the word *and* is used for the decimal point when writing names for numbers in decimal notation.

Great Question!

What am I supposed to do with the worked examples?

Study the step-by-step solutions in these examples. Reading the solutions slowly and with great care will prepare you for success with the exercises in the Exercise Sets.

EXAMPLE 2 Writing Word Names for Whole Numbers

Write a word name for the whole number in each description.

- Every day, 11,847 people get married in the United States.
- Every day in the world, 209,996,664,788 emails are sent.

(Source: *Information Everywhere*, DK Publishing, 2013)

Solution We’ve provided a place-value chart to help identify the periods.

Thousands period	Ones period
hund. tens ones	hund. tens ones
1 1	8 4 7
	,
<div style="display: flex; justify-content: space-around; margin-top: 10px;"> <div style="border: 1px solid black; border-radius: 10px; padding: 2px 5px; background-color: #e0f0ff;">eleven thousand,</div> <div style="border: 1px solid black; border-radius: 10px; padding: 2px 5px; background-color: #e0f0ff;">eight hundred forty-seven</div> </div>	

The word name for 11,847 is eleven thousand, eight hundred forty-seven.

Great Question!

Why is it so important to work each of the book's Check Points?

You learn best by doing. Do not simply look at the worked examples and conclude that you know how to solve them. To be sure you understand the worked examples, try each Check Point. Check your answer in the answer section before continuing your reading. Expect to read this text with pencil and paper handy to work the Check Points.

Great Question!

I noticed you used a comma in the word name for 6245 in Example 3. I thought we weren't using commas in four-digit numbers. What's going on?

You are correct. We are not using a comma in a four-digit number written in standard form: 6245. However, we will use a comma after the word *thousand* when we write a four-digit whole number in word form:

six thousand, two hundred forty-five.

Billions period	Millions period	Thousands period	Ones period
hund. tens ones	hund. tens ones	hund. tens ones	hund. tens ones
2 0 9	, 9 9 6	, 6 6 4	, 7 8 8
two hundred nine billion,	nine hundred ninety-six million,	six hundred sixty-four thousand,	seven hundred eighty-eight

The word name for 209,996,664,788 is two hundred nine billion, nine hundred ninety-six million, six hundred sixty-four thousand, seven hundred eighty-eight. ■

CHECK POINT 2 Write a word name for each whole number:

- 27,143
- 521,630,057

We can reverse the direction of Example 2 and write the standard form for a whole number expressed in words.

Writing the Standard Form of a Whole Number Expressed in Words

Work from left to right. Write the digits for the number in each period, followed by a comma. The comma is optional for a four-digit whole number.

EXAMPLE 3 Writing Standard Forms for Whole Numbers Expressed in Words

Write each whole number in standard form:

- six thousand, two hundred forty-five
- seventy-nine million, twenty-six thousand, one hundred two.

Solution

Thousands period	Ones period
hund. tens ones	hund. tens ones
6	, 2 4 5
six thousand,	two hundred forty-five


The standard form for six thousand, two hundred forty-five is 6,245 or 6245.

Millions period	Thousands period	Ones period
hund. tens ones	hund. tens ones	hund. tens ones
7 9	, 0 2 6	, 1 0 2
seventy-nine million,	twenty-six thousand,	one hundred two

The standard form for seventy-nine million, twenty-six thousand, one hundred two is 79,026,102. ■

CHECK POINT 3 Write each whole number in standard form:

- fifty-three thousand, four hundred six
- two hundred four million, nine hundred thirty-two thousand, sixteen.

- 3 Write whole numbers in expanded form. 

Whole Numbers in Expanded Form

The **expanded form** of a whole number breaks the number down using addition and each digit's place value. For example, consider the number 45,368.

Thousands period			Ones period		
hund.	tens	ones	hund.	tens	ones
4	5	,	3	6	8

The place-value chart shows that 45,368 contains 4 ten-thousands, 5 thousands, 3 hundreds, 6 tens, and 8 ones. Thus, 45,368 is written in expanded form as follows:

$$45,368 = 40,000 + 5,000 + 300 + 60 + 8$$

4 ten-thousands

5 thousands

3 hundreds

6 tens

8 ones

Notice how the expanded form uses the place value of each digit to express its meaning as a whole number and then uses addition to write the original number in terms of the meanings of its digits.

EXAMPLE 4 Writing Whole Numbers in Expanded Form

Write each number in expanded form:

- a. 4276 b. 32,740,945.

Solution We've provided a place-value chart to help identify the place value of each digit.

a.

Thousands period			Ones period		
hund.	tens	ones	hund.	tens	ones
4			2	7	6

$$4276 = 4000 + 200 + 70 + 6$$

4 thousands

2 hundreds

7 tens

6 ones

b.

Millions period			Thousands period			Ones period			
hund.	tens	ones	hund.	tens	ones	hund.	tens	ones	
3	2	,	7	4	0	,	9	4	5

If any digit in the standard form of a whole number is 0, it is not written as part of the addition in the number's expanded form.

$$32,740,945 = 30,000,000 + 2,000,000 + 700,000 + 40,000 + 900 + 40 + 5$$

3 ten-millions

2 millions

7 hundred-thousands

4 ten-thousands


9 hundreds

4 tens

5 ones

 **CHECK POINT 4** Write each number in expanded form:

- a. 704,663
b. 49,063,400.

- 4 Use inequality symbols to compare whole numbers. 

The Number Line and Inequality Symbols

We can visualize whole numbers, as well as other kinds of numbers, using a number line. A number line is shown in **Figure 1.2**.

We'll extend the number line to the left of 0 later in the book as we explore other kinds of numbers.

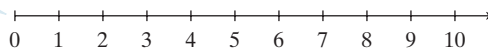


Figure 1.2 A number line

The number line in **Figure 1.2** has equally spaced marks to represent each whole number. The arrowhead on the right indicates that the whole numbers continue indefinitely. As you know, there is no greatest whole number. The lack of an arrowhead on the left indicates that 0 is the smallest whole number.

We **graph**, or **plot**, a whole number on a number line by placing a dot (\cdot) at the correct location for that number. For example, the whole numbers 2 and 6 are graphed in **Figure 1.3**.

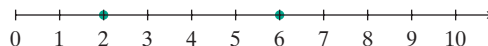


Figure 1.3 Graphing 2 and 6 on a number line

On a number line, the whole numbers increase in value from left to right. The lesser of two whole numbers is the one farther to the left on a number line. The greater of two whole numbers is the one farther to the right.

Look at the number line in **Figure 1.3** where we plotted the numbers 2 and 6. Observe that 2 is to the *left* of 6 on the number line. This means that 2 is less than 6.

$2 < 6$: 2 is less than 6 because 2 is to the *left* of 6 on the number line.

In **Figure 1.3**, we can also observe that 6 is to the *right* of 2 on the number line. This means that 6 is greater than 2.

$6 > 2$: 6 is greater than 2 because 6 is to the *right* of 2 on the number line.

The symbols $<$ and $>$ are called **inequality symbols**. These symbols always point to the lesser of two whole numbers when the inequality is true.

2 is less than 6.

$$2 < 6$$

The inequality symbol points to 2, the lesser number.

6 is greater than 2.

$$6 > 2$$

The inequality symbol still points to 2, the lesser number.

Inequality Symbols

Reading from left to right,

the symbol $<$ means *is less than*.

the symbol $>$ means *is greater than*.

EXAMPLE 5 Using Inequality Symbols

Insert either $<$ or $>$ in the shaded area between each pair of whole numbers to make a true statement.

a. 3 14

b. 12 2

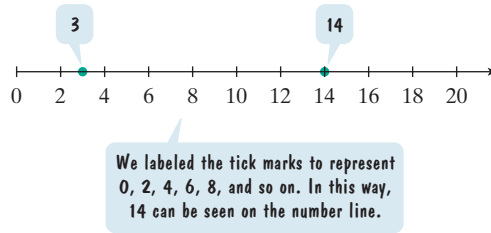
Great Question!

When I compare two whole numbers, do I actually have to graph them? Or is it ok to picture the graphs in my head?

It's ok to visualize the graphs mentally. This is particularly useful when the whole numbers are relatively large.

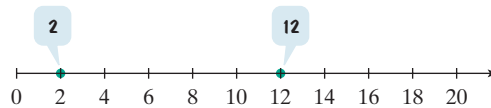
Solution In each case, compare the graph of the first number to the graph of the second number. If the first number is to the left of the second number on a number line, insert the symbol $<$ for “is less than.” If the first number is to the right of the second number, insert the symbol $>$ for “is greater than.”

- a. Compare the graphs of 3 and 14 on a number line.



Because 3 is to the left of 14, this means that 3 is less than 14: $3 < 14$.

- b. Compare the graphs of 12 and 2 on a number line.



Because 12 is to the right of 2, this means that 12 is greater than 2: $12 > 2$. ■

✓ CHECK POINT 5 Insert either $<$ or $>$ in the shaded area between each pair of whole numbers to make a true statement.

a. 14 5

b. 0 16

5 Round whole numbers.

Rounding Whole Numbers

Estimation is the process of arriving at an approximate answer to a question. For example, if the price of a computer is \$589, it may be easier to think of it as \$590 or \$600. These rounded numbers, \$590 or \$600, are called **approximations** or **estimates**.

Performing computations using rounded whole numbers is one way to check whether an answer displayed by a calculator or computer is reasonable. Here are the rules for rounding whole numbers:

Rounding Whole Numbers

1. Look at the digit to the right of the digit where rounding is to occur.
2.
 - a. If the digit to the right is 5 or greater, add 1 to the digit to be rounded. Replace all digits to the right with zeros.
 - b. If the digit to the right is less than 5, do not change the digit to be rounded. Replace all digits to the right with zeros.

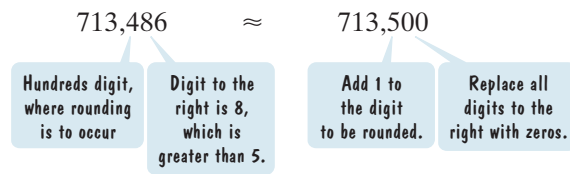
The symbol \approx means *is approximately equal to*. We will use this symbol when rounding numbers.

EXAMPLE 6 Rounding Whole Numbers

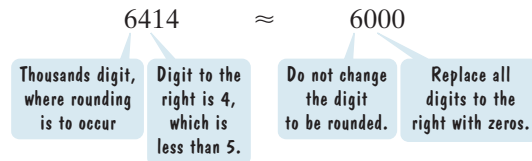
- a. Round 713,486 to the nearest hundred.
- b. Round 6414 to the nearest thousand.
- c. Round 9517 to the nearest thousand.
- d. Round 172,406 to the nearest ten-thousand.
- e. Round 23,604,972 to the nearest million.

Solution

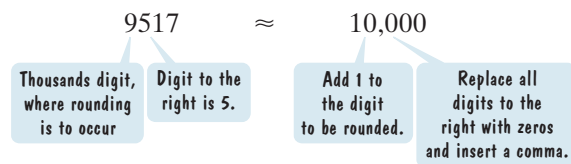
- a. Rounding to the nearest hundred



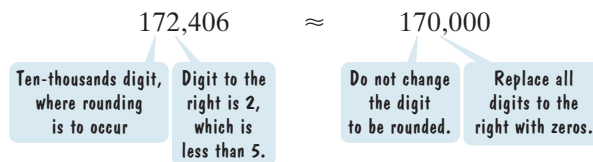
- b. Rounding to the nearest thousand



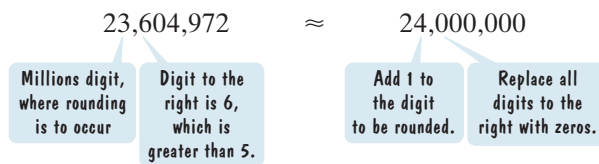
- c. Rounding to the nearest thousand



- d. Rounding to the nearest ten-thousand



- e. Rounding to the nearest million

**✓ CHECK POINT 6**

- Round 57,498 to the nearest thousand.
- Round 4,856,902 to the nearest hundred-thousand.
- Round 9602 to the nearest thousand.
- Round 684,236,042 to the nearest million.

EXAMPLE 7 Rounding World Population

This example uses world population on January 10, 2013.

World population: 7,058,746,857

Seven billion, fifty-eight million, seven hundred forty-six thousand, eight hundred fifty-seven

Round world population (7,058,746,857) as follows:

- to the nearest hundred-million
- to the nearest million
- to the nearest hundred-thousand.