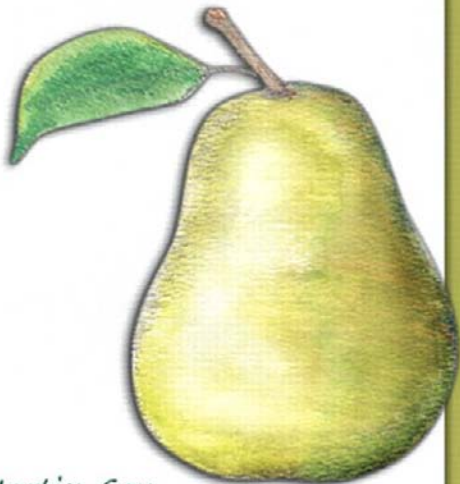


# Intermediate Algebra

SIXTH EDITION



*Elayn Martin-Gay*

*This page intentionally left blank*

# Intermediate Algebra

*This page intentionally left blank*

# Intermediate Algebra

*Sixth Edition*

*Elayn Martin-Gay*

*University of New Orleans*

**PEARSON**

Boston Columbus Indianapolis New York San Francisco Upper Saddle River  
Amsterdam Cape Town Dubai London Madrid Milan Munich Paris Montréal Toronto  
Delhi Mexico City São Paulo Sydney Hong Kong Seoul Singapore Taipei Tokyo

**Editorial Director, Mathematics:** *Christine Hoag*  
**Acquisitions Editor:** *Mary Beckwith*  
**Executive Content Editor:** *Kari Heen*  
**Associate Content Editor:** *Christine Whitlock*  
**Editorial Assistant:** *Matthew Summers*  
**Executive Director, Development:** *Carol Trueheart*  
**Senior Development Editor:** *Dawn Nuttall*  
**Senior Managing Editor:** *Karen Wernholm*  
**Production Project Manager:** *Patty Bergin*  
**Senior Design Specialist:** *Heather Scott*  
**Associate Director of Design, USHE North and West:** *Andrea Nix*  
**Digital Assets Manager:** *Marianne Groth*  
**Supplements Production Project Manager:** *Katherine Roz*  
**Executive Manager, Course Production:** *Peter Silvia*  
**Media Producer:** *Audra Walsh*  
**Director of Content Development:** *Rebecca Williams*  
**Content Project Supervisor:** *Janet Szykowny*  
**Executive Marketing Manager:** *Michelle Renda*  
**Marketing Assistant:** *Susan Mai*  
**Senior Author Support/Technology Specialist:** *Joe Vetere*  
**Senior Media Buyer:** *Ginny Michaud*  
**Permissions Project Supervisor:** *Michael Joyce*  
**Procurement Specialist:** *Linda Cox*  
**Production Management, Interior Design, Composition, and Answer Art:** *Integra*  
**Text Art:** *Scientific Illustrators*  
**Cover Design and Image:** *Tamara Newnam*

Many of the designations used by manufacturers and sellers to distinguish their products are claimed as trademarks. Where those designations appear in this book, and Pearson Education was aware of a trademark claim, the designations have been printed in initial caps or all caps.

**Library of Congress Cataloging-in-Publication Data**

Martin-Gay, K. Elayn  
 Intermediate algebra / Elayn Martin-Gay.—6th ed.  
 p. cm.  
 ISBN-13: 978-0-321-78504-6  
 ISBN-10: 0-321-78504-5  
 1. Algebra—Textbooks. I. Title.  
 QA152.3.M36 2013  
 512.9—dc23  
 2011013318

Copyright © 2013, 2009, 2005, 2002 Pearson Education, Inc.

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the prior written permission of the publisher. Printed in the United States of America. For information on obtaining permission for use of material in this work, please submit a written request to Pearson Education, Inc., Rights and Contracts Department, 501 Boylston Street, Suite 900, Boston, MA 02116, fax your request to 617-671-3447, or e-mail at <http://www.pearsoned.com/legal/permissions.htm>.

1 2 3 4 5 6 7 8 9 10—CRK—15 14 13 12 11



This book is dedicated to students everywhere—and we should all be students. After all, is there anyone among us who really knows too much? Take that hint and continue to learn something new every day of your life.

Best of wishes from a fellow student: Elayn Martin-Gay

# Contents

Preface xiv  
Applications Index xxii

## CHAPTER 1 REAL NUMBERS AND ALGEBRAIC EXPRESSIONS 1

# 1

- 1.1 Tips for Success in Mathematics 2
- 1.2 Algebraic Expressions and Sets of Numbers 7
- 1.3 Operations on Real Numbers and Order of Operations 17  
[Integrated Review—Algebraic Expressions and Operations on Whole Numbers](#) 29
- 1.4 Properties of Real Numbers and Algebraic Expressions 30
  - Chapter 1 Vocabulary Check* 41
  - Chapter 1 Highlights* 41
  - Chapter 1 Review* 43
  - Chapter 1 Test* 46

## CHAPTER 2 EQUATIONS, INEQUALITIES, AND PROBLEM SOLVING 47

# 2

- 2.1 Linear Equations in One Variable 48
- 2.2 An Introduction to Problem Solving 57
- 2.3 Formulas and Problem Solving 69
- 2.4 Linear Inequalities and Problem Solving 77  
[Integrated Review—Linear Equations and Inequalities](#) 88
- 2.5 Compound Inequalities 89
- 2.6 Absolute Value Equations 96
- 2.7 Absolute Value Inequalities 101
  - Chapter 2 Vocabulary Check* 107
  - Chapter 2 Highlights* 107
  - Chapter 2 Review* 111
  - Chapter 2 Test* 113
  - Chapter 2 Cumulative Review* 114

## CHAPTER 3 GRAPHS AND FUNCTIONS 116

# 3

- 3.1 Graphing Equations 117
- 3.2 Introduction to Functions 128
- 3.3 Graphing Linear Functions 144
- 3.4 The Slope of a Line 152
- 3.5 Equations of Lines 165  
[Integrated Review—Linear Equations in Two Variables](#) 175
- 3.6 Graphing Piecewise-Defined Functions and Shifting and Reflecting Graphs of Functions 176
- 3.7 Graphing Linear Inequalities 184
  - Chapter 3 Vocabulary Check* 189
  - Chapter 3 Highlights* 189
  - Chapter 3 Review* 194
  - Chapter 3 Test* 198
  - Chapter 3 Cumulative Review* 199



## CHAPTER SYSTEMS OF EQUATIONS 201

## 4

- 4.1 Solving Systems of Linear Equations in Two Variables 202
- 4.2 Solving Systems of Linear Equations in Three Variables 214
- 4.3 Systems of Linear Equations and Problem Solving 221  
*Integrated Review—Systems of Linear Equations* 234
- 4.4 Solving Systems of Equations by Matrices 235
- 4.5 Systems of Linear Inequalities 241  
*Chapter 4 Vocabulary Check* 244  
*Chapter 4 Highlights* 245  
*Chapter 4 Review* 249  
*Chapter 4 Test* 251  
*Chapter 4 Cumulative Review* 252

## CHAPTER EXPONENTS, POLYNOMIALS, AND POLYNOMIAL FUNCTIONS 254

## 5

- 5.1 Exponents and Scientific Notation 255
- 5.2 More Work with Exponents and Scientific Notation 264
- 5.3 Polynomials and Polynomial Functions 270
- 5.4 Multiplying Polynomials 282
- 5.5 The Greatest Common Factor and Factoring by Grouping 291
- 5.6 Factoring Trinomials 297
- 5.7 Factoring by Special Products 305  
*Integrated Review—Operations on Polynomials and Factoring Strategies* 310
- 5.8 Solving Equations by Factoring and Problem Solving 314  
*Chapter 5 Vocabulary Check* 326  
*Chapter 5 Highlights* 327  
*Chapter 5 Review* 329  
*Chapter 5 Test* 332  
*Chapter 5 Cumulative Review* 333

## CHAPTER RATIONAL EXPRESSIONS 335

## 6

- 6.1 Rational Functions and Multiplying and Dividing Rational Expressions 336
- 6.2 Adding and Subtracting Rational Expressions 348
- 6.3 Simplifying Complex Fractions 356
- 6.4 Dividing Polynomials: Long Division and Synthetic Division 362
- 6.5 Solving Equations Containing Rational Expressions 372  
*Integrated Review—Expressions and Equations Containing Rational Expressions* 379
- 6.6 Rational Equations and Problem Solving 381
- 6.7 Variation and Problem Solving 390  
*Chapter 6 Vocabulary Check* 399  
*Chapter 6 Highlights* 400  
*Chapter 6 Review* 403  
*Chapter 6 Test* 406  
*Chapter 6 Cumulative Review* 407

## CHAPTER RATIONAL EXPONENTS, RADICALS, AND COMPLEX NUMBERS 409

## 7

- 7.1 Radicals and Radical Functions 410
- 7.2 Rational Exponents 419
- 7.3 Simplifying Radical Expressions 426
- 7.4 Adding, Subtracting, and Multiplying Radical Expressions 434
- 7.5 Rationalizing Denominators and Numerators of Radical Expressions 440  
*Integrated Review—Radicals and Rational Exponents* 446
- 7.6 Radical Equations and Problem Solving 447
- 7.7 Complex Numbers 457  
*Chapter 7 Vocabulary Check* 464

*Chapter 7 Highlights* 464  
*Chapter 7 Review* 468  
*Chapter 7 Test* 470  
*Chapter 7 Cumulative Review* 471

CHAPTER **QUADRATIC EQUATIONS AND FUNCTIONS** 474

# 8

- 8.1 Solving Quadratic Equations by Completing the Square 475
- 8.2 Solving Quadratic Equations by the Quadratic Formula 485
- 8.3 Solving Equations by Using Quadratic Methods 495
- [Integrated Review—Summary on Solving Quadratic Equations](#) 504
- 8.4 Nonlinear Inequalities in One Variable 505
- 8.5 Quadratic Functions and Their Graphs 512
- 8.6 Further Graphing of Quadratic Functions 520
- Chapter 8 Vocabulary Check* 528
- Chapter 8 Highlights* 528
- Chapter 8 Review* 531
- Chapter 8 Test* 532
- Chapter 8 Cumulative Review* 533

CHAPTER **EXPONENTIAL AND LOGARITHMIC FUNCTIONS** 535

# 9

- 9.1 The Algebra of Functions; Composite Functions 536
- 9.2 Inverse Functions 541
- 9.3 Exponential Functions 552
- 9.4 Exponential Growth and Decay Functions 561
- 9.5 Logarithmic Functions 565
- 9.6 Properties of Logarithms 573
- [Integrated Review—Functions and Properties of Logarithms](#) 579
- 9.7 Common Logarithms, Natural Logarithms, and Change of Base 580
- 9.8 Exponential and Logarithmic Equations and Problem Solving 586
- Chapter 9 Vocabulary Check* 592
- Chapter 9 Highlights* 593
- Chapter 9 Review* 596
- Chapter 9 Test* 598
- Chapter 9 Cumulative Review* 600

CHAPTER **CONIC SECTIONS** 602

# 10

- 10.1 The Parabola and the Circle 603
- 10.2 The Ellipse and the Hyperbola 612
- [Integrated Review—Graphing Conic Sections](#) 619
- 10.3 Solving Nonlinear Systems of Equations 620
- 10.4 Nonlinear Inequalities and Systems of Inequalities 625
- Chapter 10 Vocabulary Check* 629
- Chapter 10 Highlights* 629
- Chapter 10 Review* 632
- Chapter 10 Test* 633
- Chapter 10 Cumulative Review* 633

CHAPTER **SEQUENCES, SERIES, AND THE BINOMIAL THEOREM** 635

# 11

- 11.1 Sequences 636
- 11.2 Arithmetic and Geometric Sequences 640
- 11.3 Series 648
- [Integrated Review—Sequences and Series](#) 653
- 11.4 Partial Sums of Arithmetic and Geometric Sequences 653
- 11.5 The Binomial Theorem 660

<i>Chapter 11 Vocabulary Check</i>	665
<i>Chapter 11 Highlights</i>	665
<i>Chapter 11 Review</i>	667
<i>Chapter 11 Test</i>	669
<i>Chapter 11 Cumulative Review</i>	669

## APPENDICES

A	GEOMETRY	671
B	STRETCHING AND COMPRESSING GRAPHS OF ABSOLUTE VALUE FUNCTIONS	678
C	SOLVING SYSTEMS OF EQUATIONS USING DETERMINANTS	680
D	AN INTRODUCTION TO USING A GRAPHING UTILITY	687
E	CONTENTS OF STUDENT RESOURCES	692

Answers to Selected Exercises A1

Index I1

Photo Credits P1

# Student Resources

These resources, located in the back of the text, give you a variety of tools conveniently located in one place to help you succeed in math.

## Study Skills Builders

### Attitude and Study Tips:

1. Have You Decided to Complete This Course Successfully?
2. Tips for Studying for an Exam
3. What to Do the Day of an Exam
4. Are You Satisfied with Your Performance on a Particular Quiz or Exam?
5. How Are You Doing?
6. Are You Preparing for Your Final Exam?

### Organizing Your Work:

7. Learning New Terms
8. Are You Organized?
9. Organizing a Notebook
10. How Are Your Homework Assignments Going?

### MyMathLab and MathXL:

11. Tips for Turning in Your Homework on Time
12. Tips for Doing Your Homework Online
13. Organizing Your Work
14. Getting Help with Your Homework Assignments
15. Tips for Preparing for an Exam
16. How Well Do You Know the Resources Available to You in MyMathLab?

### Additional Help Inside and Outside Your Textbook:

17. How Well Do You Know Your Textbook?
18. Are You Familiar with Your Textbook Supplements?
19. Are You Getting All the Mathematics Help That You Need?

## Bigger Picture—Study Guide Outline

## Practice Final Exam

## Answers to Selected Exercises

# A New Tool to Help You Succeed

## Introducing Martin-Gay's New Student Organizer

The new **Student Organizer** guides you through three important parts of studying effectively—note-taking, practice, and homework.

It is designed to help you organize your learning materials and develop the study habits you need to be successful. The Student Organizer includes:

- How to prepare for class
- Space to take class notes
- Step-by-step worked examples
- Your Turn exercises (modeled after the examples)
- Answers to the Your Turn exercises as well as worked-out solutions via references to the Martin-Gay text and videos
- Helpful hints and directions for completing homework assignments

A flexible design allows instructors to assign any or all parts of the Student Organizer.

The Student Organizer is available in a loose-leaf, notebook-ready format. It is also available for download in MyMathLab.

For more information, please go to

[www.pearsonhighered.com/martingay](http://www.pearsonhighered.com/martingay)

[www.mypearsonstore.com](http://www.mypearsonstore.com)

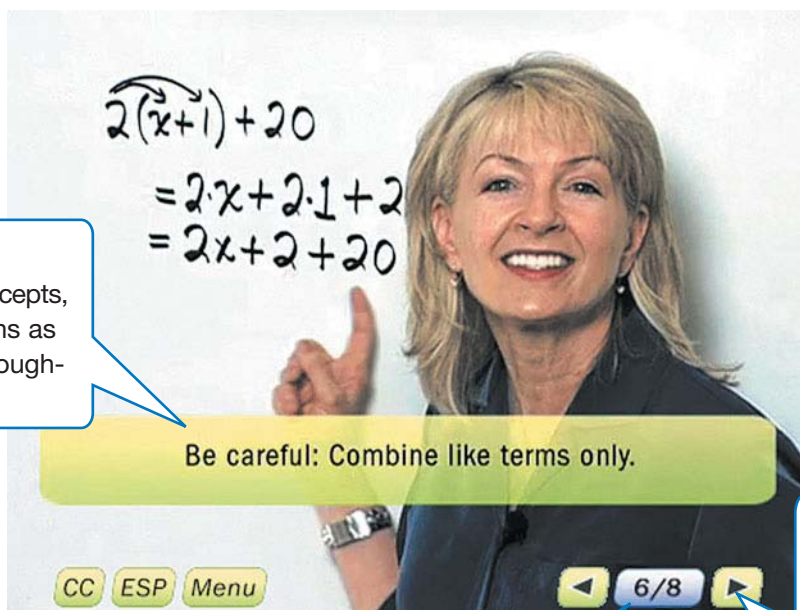
(search Martin-Gay, Intermediate Algebra, Sixth Edition)  
your Martin-Gay MyMathLab® course

# Martin-Gay Video Resources to Help You Succeed

## Interactive DVD Lecture Series

### Active Learning at Your Pace

Designed for use on your computer or DVD player, these interactive videos include a 15–20 minute lecture for every section in the text as well as Concept Checks, Study Skills Builders, and a Practice Final Exam.



#### Pop-ups

Take note of key concepts, terms, and definitions as pop-ups appear throughout each section.

Be careful: Combine like terms only.

#### Exercises

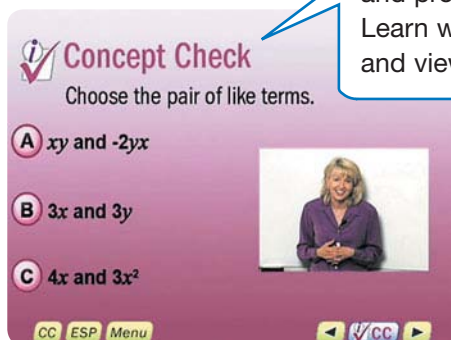
Know how to do an exercise? Click the “next” arrow to skip ahead or the “back” arrow to review an exercise.

#### Progress Meter

Monitor your progress through the lecture and exercises at a glance.

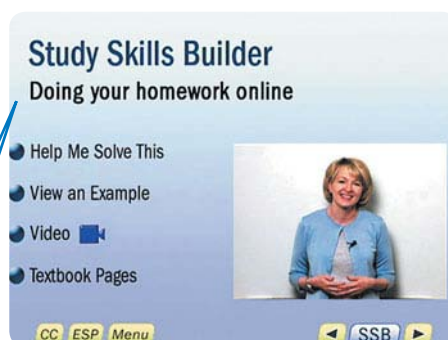
#### Interactive Concept Checks

pose questions about key concepts and prompt you to click on an answer. Learn whether your answer is correct and view the full solution.



#### Study Skills Builders

provide tips and suggestions to help you develop effective study habits.

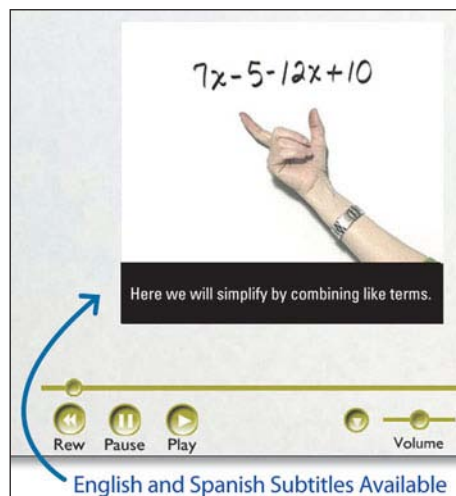


## Chapter Test Prep Videos

Step-by-step solutions on video for all chapter test exercises from the text.

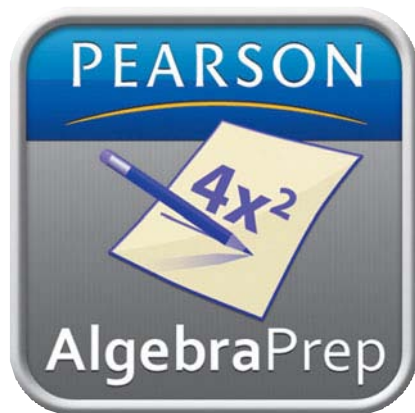
Available via:

- Interactive DVD Lecture Series
- MyMathLab®
- YouTube™

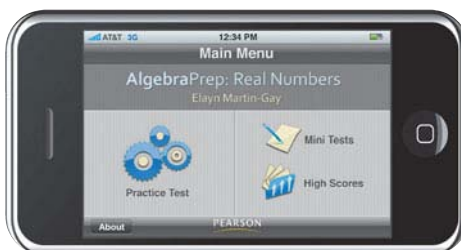


## AlgebraPrep Apps for the iPhone™ and iPod Touch®

Your 24/7 Algebra Tutor—Anytime, Anywhere!



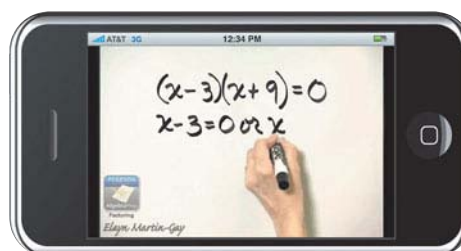
Available on the iPhone  
App Store



- ◀ Choose to take a Practice Test or a MiniTest (designed to take 10 minutes or less).



- ◀ Practice Test exercises provide answer feedback to help you study and self-correct.



- ◀ Step-by-step video solutions give you the guidance of an expert tutor whenever you need help.

# Preface

*Intermediate Algebra, Sixth Edition*, was written to provide a solid foundation in algebra for students who might not have previous experience in algebra. Specific care was taken to make sure students have the most up-to-date, relevant text preparation for their next mathematics course or for nonmathematical courses that require an understanding of algebraic fundamentals. I have tried to achieve this by writing a user-friendly text that is keyed to objectives and contains many worked-out examples. As suggested by AMATYC and the NCTM Standards (plus Addenda), real-life and real-data applications, data interpretation, conceptual understanding, problem solving, writing, cooperative learning, appropriate use of technology, mental mathematics, number sense, estimation, critical thinking, and geometric concepts are emphasized and integrated throughout the book.

The many factors that contributed to the success of the previous editions have been retained. In preparing the Sixth Edition, I considered comments and suggestions of colleagues, students, and many users of the prior edition throughout the country.

## What's New in the Sixth Edition?

- **The Martin-Gay Program** has been revised and enhanced with a new design in the text and MyMathLab to actively encourage students to use the text, video program, and Student Organizer as an integrated learning system.
  - **The Student Organizer** is designed by me to help students develop the study habits they need to be successful. This Organizer guides students through the three main components of studying effectively—note-taking, practice, and homework—and helps them develop the habits that will enable them to succeed in future courses. The Student Organizer can be packaged with the text in loose-leaf, notebook-ready format and is also available for download in MyMathLab.
  - **New Vocabulary, Readiness & Video Check** questions have been added prior to every section exercise set. These exercises quickly check a student's understanding of new vocabulary words. The **readiness** exercises center on a student's understanding of a concept that is necessary in order to continue to the exercise set. **New video check questions for the Martin-Gay Interactive Lecture videos** are now included in every section for each learning objective. **These exercises are all available for assignment in MyMathLab** and are a great way to assess whether students have viewed and understood the key concepts presented in the videos.
  - **The Interactive DVD Lecture Series**, featuring your text author (Elayn Martin-Gay), provides students with active learning at their own pace. The videos offer the following resources and more:
    - **A complete lecture for each section of the text** highlights key examples and exercises from the text. New “pop-ups” reinforce key terms, definitions, and concepts.
    - **An interface with menu navigation features** allows students to quickly find and focus on the examples and exercises they need to review.
    - **Interactive Concept Check** exercises measure students' understanding of key concepts and common trouble spots.
- The Interactive DVD Lecture Series also includes the following resources for test prep:**
- **The Practice Final Exam** helps students prepare for an end-of-course final. Students can watch full video solutions to each exercise.



**The Chapter Test Prep Videos** help students during their most teachable moment—when they are preparing for a test. This innovation provides step-by-step solutions for the Chapter Test exercises found at the end of each chapter in the text. The videos are captioned in English and Spanish. For the Sixth Edition, the chapter test prep videos are also available on YouTube™.

- **The Martin-Gay MyMathLab course** has been updated and revised to provide more exercise coverage, including assignable video check questions, and an expanded video program. There are section lecture videos for every section, students can also access at the specific objective level, and there are an increased number of watch clips at the exercise level to help students while doing homework in MathXL. Suggested homework assignments have been premade for assignment at the instructor’s discretion.
- **New MyMathLab Ready to Go courses** (access code required) provide students with all the same great MyMathLab features that you’re used to, but make it easier for instructors to get started. Each course includes preassigned homework and quizzes to make creating your course even simpler. Ask your Pearson representative about the details for this particular course or to see a copy of this course.
- **A new section (9.4)** devoted specifically to exponential growth and decay and applications has been added. This section includes the definition and examples of half-life.
- **The new Student Resources** section, located in the back of the text, gives students a variety of tools that are conveniently located in one place to help them achieve success in math.
  - **Study Skills Builders** give students tips and suggestions on successful study habits and help them take responsibility for their learning. Assignable exercises check students’ progress in improving their skills.
  - The **Bigger Picture—Study Guide Outline** covers key concepts of the course—simplifying expressions and solving equations and inequalities—to help students transition from thinking section-by-section to thinking about how the material they are learning fits into mathematics as a whole. This outline provides a model for students on how to organize and develop their own study guide.
  - The **Practice Final Exam** helps students prepare for the end-of-the-course exam. Students can also watch the step-by-step solutions to all the Practice Final Exam exercises on the new Interactive DVD Lecture Series and in MyMathLab.
  - The **Answers to Selected Exercises** section allows students to check their answers for all Practice exercises; odd-numbered Vocabulary, Readiness & Video Check exercises; odd-numbered section exercises; Chapter Review and Cumulative Review exercises; and all Integrated Review and Chapter Test exercises.
- **New guided application exercises** appear in many sections throughout the text, beginning with Section 2.2. These applications prompt students on how to set up the application and get started with the solution process. These guided exercises will help students prepare to solve application exercises on their own.
- **Enhanced emphasis on Study Skills** helps students develop good study habits and makes it more convenient for instructors to incorporate or assign study skills in their courses. The following changes have been made in the Sixth Edition:
 

Section 1.1, Tips for Success in Mathematics, has been updated to include helpful hints for doing homework online in MyMathLab. Exercises pertaining to doing homework online in MyMathLab are now included in the exercise set for 1.1.

The Study Skills Builders, formerly located at the end of select exercise sets, are now included in the new **Student Resources** section at the back of the book and organized by topic for ease of assignment. This section now also includes new Study Skills Builders on doing homework online in MyMathLab.

- All exercise sets have been reviewed and updated to ensure that even- and odd-numbered exercises are paired.

## Key Pedagogical Features

The following key features have been retained and/or updated for the Sixth Edition of the text:

**Problem-Solving Process** This is formally introduced in Chapter 2 with a four-step process that is integrated throughout the text. The four steps are **Understand, Translate, Solve,** and **Interpret.** The repeated use of these steps in a variety of examples shows their wide applicability. Reinforcing the steps can increase students' comfort level and confidence in tackling problems.

**Exercise Sets Revised and Updated** The exercise sets have been carefully examined and extensively revised. Special focus was placed on making sure that even- and odd-numbered exercises are paired.

**Examples** Detailed, step-by-step examples were added, deleted, replaced, or updated as needed. Many of these reflect real life. Additional instructional support is provided in the annotated examples.

**Practice Exercises** Throughout the text, each worked-out example has a parallel Practice Exercise. These invite students to be actively involved in the learning process. Students should try each Practice Exercise after finishing the corresponding example. Learning by doing will help students grasp ideas before moving on to other concepts. Answers to the Practice Exercises are provided in the back of the text.

**Helpful Hints** Helpful Hints contain practical advice on applying mathematical concepts. Strategically placed where students are most likely to need immediate reinforcement, Helpful Hints help students avoid common trouble areas and mistakes.

**Concept Checks** This feature allows students to gauge their grasp of an idea as it is being presented in the text. Concept Checks stress conceptual understanding at the point-of-use and help suppress misconceived notions before they start. Answers appear at the bottom of the page. Exercises related to Concept Checks are included in the exercise sets.

**Mixed Practice Exercises** Found in the section exercise sets, each requires students to determine the problem type and strategy needed to solve it just as they would need to do on a test.

**Integrated Reviews** A unique, mid-chapter exercise set that helps students assimilate new skills and concepts that they have learned separately over several sections. These reviews provide yet another opportunity for students to work with “mixed” exercises as they master the topics.

**Vocabulary Check** Provides an opportunity for students to become more familiar with the use of mathematical terms as they strengthen their verbal skills. These appear at the end of each chapter before the Chapter Highlights. Vocabulary, Readiness & Video Check exercises also provide vocabulary practice at the section level.

**Chapter Highlights** Found at the end of every chapter, these contain key definitions and concepts with examples to help students understand and retain what they have learned and help them organize their notes and study for tests.

**Chapter Review** The end of every chapter contains a comprehensive review of topics introduced in the chapter. The Chapter Review offers exercises keyed to every section in the chapter, as well as Mixed Review exercises that are not keyed to sections.

**Chapter Test and Chapter Test Prep Video** The Chapter Test is structured to include those problems that involve common student errors. The **Chapter Test Prep Videos** give students instant access to a step-by-step video solution of each exercise in the Chapter Test.

**Cumulative Review** Follows every chapter in the text (except Chapter 1). Each odd-numbered exercise contained in the Cumulative Review is an earlier worked example in the text that is referenced in the back of the book along with the answer.

**Writing Exercises** ✎ These exercises occur in almost every exercise set and require students to provide a written response to explain concepts or justify their thinking.

**Applications** Real-world and real-data applications have been thoroughly updated and many new applications are included. These exercises occur in almost every exercise set and show the relevance of mathematics and help students gradually, and continuously, develop their problem-solving skills.





**Review and Preview Exercises** These exercises occur in each exercise set (except in Chapter 1) and are keyed to earlier sections. They review concepts learned earlier in the text that will be needed in the next section or chapter.


**Exercise Set Resource Icons** Located at the opening of each exercise set, these icons remind students of the resources available for extra practice and support:



See Student Resources descriptions on page xviii for details on the individual resources available.

**Exercise Icons** These icons facilitate the assignment of specialized exercises and let students know what resources can support them.

-  Video icon: exercise worked on the Interactive DVD Lecture Series and in MyMathLab.
-  Triangle icon: identifies exercises involving geometric concepts.
-  Pencil icon: indicates a written response is needed.
-  Calculator icon: optional exercises intended to be solved using a scientific or graphing calculator.

**Optional: Calculator Exploration Boxes and Calculator Exercises** The optional Calculator Explorations provide key strokes and exercises at appropriate points to give an opportunity for students to become familiar with these tools. Section exercises that are best completed by using a calculator are identified by  for ease of assignment.

## Student and Instructor Resources

### STUDENT RESOURCES

<p><b>Student Organizer</b></p> <p>Guides students through the 3 main components of studying effectively—note-taking, practice, and homework.</p> <p>The organizer includes before-class preparation exercises, note-taking pages in a 2-column format for use in class, and examples paired with exercises for practice for each section. It is 3-hole-punched. Also available in MyMathLab.</p>	<p><b>Student Solutions Manual</b></p> <p>Provides complete worked-out solutions to</p> <ul style="list-style-type: none"> <li>the odd-numbered section exercises; all Practice Exercises; all exercises in the Integrated Reviews, Chapter Reviews, Chapter Tests, and Cumulative Reviews</li> </ul>
<p><b>Interactive DVD Lecture Series</b></p> <p>Provides students with active learning at their pace. The videos offer:</p> <ul style="list-style-type: none"> <li>A complete lecture for each text section. The interface allows easy navigation to examples and exercises students need to review.</li> <li>Interactive Concept Check exercises</li> <li>Study Skills Builders</li> <li>Practice Final Exam</li> <li>Chapter Test Prep Videos</li> </ul>	<p><b>Chapter Test Prep Videos</b></p> <ul style="list-style-type: none"> <li>Step-by-step solutions to every exercise in each Chapter Practice Test.</li> <li>Available in MyMathLab<sup>®</sup> and on YouTube, and in the Interactive DVD Lecture Series.</li> </ul>

### INSTRUCTOR RESOURCES

<p><b>Annotated Instructor's Edition</b></p> <p>Contains all the content found in the student edition, plus the following:</p> <ul style="list-style-type: none"> <li>Answers to exercises on the same text page</li> <li>Answers to graphing exercises and all video exercises</li> <li>Teaching Tips throughout the text placed at key points.</li> <li>Classroom Examples in the margin paired to each example in the text.</li> </ul>	<p><b>Instructor's Resource Manual with Tests and Mini-Lectures</b></p> <ul style="list-style-type: none"> <li>Mini-lectures for each text section</li> <li>Additional Practice worksheets for each section</li> <li>Several forms of test per chapter—free response and multiple choice</li> <li>Group activities</li> <li>Video key to the example number in the video questions and section exercises worked in the videos</li> <li>Answers to all items</li> </ul> <p><b>Instructor's Solutions Manual</b>  <b>TestGen<sup>®</sup></b> (Available for download from the IRC)</p>
	<p><b>Online Resources</b></p> <p><b>MyMathLab<sup>®</sup></b> (access code required)</p> <p><b>MathXL<sup>®</sup></b> (access code required)</p>

## Acknowledgments

There are many people who helped me develop this text, and I will attempt to thank some of them here. Cindy Trimble and Carrie Green were *invaluable* for contributing to the overall accuracy of the text. Dawn Nuttall, Courtney Slade, and JoAnne Thomasson were *invaluable* for their many suggestions and contributions during the development and writing of this Sixth Edition. Debbie Meyer and Amanda Zagnoli of Integra-Chicago provided guidance throughout the production process.

A very special thank you goes to my editor, Mary Beckwith, for being there 24/7/365, as my students say. Last, my thanks to the staff at Pearson for all their support: Patty Bergin, Heather Scott, Michelle Renda, Chris Hoag, and Greg Tobin.

I would like to thank the following reviewers for their input and suggestions:

Sandi Athanassiou, *University of Missouri-Columbia*  
 Michelle Beerman, *Pasco-Hernandez Community College*  
 Monika Bender, *Central Texas College*  
 Bob Hervey, *Hillsborough Community College*  
 Michael Maltenfort, *Truman College*  
 Jorge Romero, *Hillsborough Community College*  
 Joseph Wakim, *Brevard Community College*  
 Flo Wilson, *Central Texas College*  
 Marie Caruso and students, *Middlesex Community College*

I would also like to thank the following dedicated group of instructors who participated in our focus groups, Martin-Gay Summits, and our design review for the series. Their feedback and insights have helped to strengthen this edition of the text. These instructors include:

Billie Anderson, *Tyler Junior College*  
 Joey Anderson, *Central Piedmont Community College*  
 Cedric Atkins, *Mott Community College*  
 Teri Barnes, *McLennan Community College*  
 Andrea Barnett, *Tri-County Technical College*  
 Lois Beardon, *Schoolcraft College*  
 Michelle Beerman, *Pasco-Hernandez Community College*  
 Laurel Berry, *Bryant & Stratton College*  
 John Beyers, *University of Maryland*  
 Jennifer Brahier, *Pensacola Junior College*  
 Bob Brown, *Community College of Baltimore County–Essex*  
 Lisa Brown, *Community College of Baltimore County–Essex*  
 NeKeith Brown, *Richland College*  
 Sue Brown, *Guilford Technical Community College*  
 Gail Burkett, *Palm Beach State College*  
 Cheryl Cantwell, *Seminole Community College*  
 Janie Chapman, *Spartanburg Community College*  
 Jackie Cohen, *Augusta State College*  
 Julie Dewan, *Mohawk Valley Community College*  
 Janice Ervin, *Central Piedmont Community College*  
 Karen Estes, *St. Petersburg College*  
 Richard Fielding, *Southwestern College*  
 Sonia Ford, *Midland College*  
 Julie Francavilla, *State College of Florida*  
 Cindy Gaddis, *Tyler Junior College*  
 Nita Graham, *St. Louis Community College*  
 Pauline Hall, *Iowa State College*  
 Elizabeth Hamman, *Cypress College*  
 Kathy Hoffmaster, *Thomas Nelson Community College*  
 Pat Hussey, *Triton College*  
 Dorothy Johnson, *Lorain County Community College*  
 Sonya Johnson, *Central Piedmont Community College*

Irene Jones, *Fullerton College*  
Paul Jones, *University of Cincinnati*  
Mike Kirby, *Tidewater Community College*  
Kathy Kopelousos, *Lewis and Clark Community College*  
Nancy Lange, *Inver Hills Community College*  
Judy Langer, *Westchester Community College*  
Lisa Lindloff, *McLennan Community College*  
Sandy Lofstock, *St. Petersburg College*  
Kathy Lovelle, *Westchester Community College*  
Jamie Malek, *Florida State College*  
Jean McArthur, *Joliet Junior College*  
Kevin McCandless, *Evergreen Valley College*  
Daniel Miller, *Niagara County Community College*  
Marcia Molle, *Metropolitan Community College*  
Carol Murphy, *San Diego Miramar College*  
Charlotte Newsom, *Tidewater Community College*  
Greg Nguyen, *Fullerton College*  
Eric Ollila, *Jackson Community College*  
Linda Padilla, *Joliet Junior College*  
Rena Petrello, *Moorpark College*  
Davidson Pierre, *State College of Florida*  
Marilyn Platt, *Gaston College*  
Susan Poss, *Spartanburg Community College*  
Natalie Rivera, *Estrella Mountain Community College*  
Judy Roane, *Pearl River Community College*  
Claudinna Rowley, *Montgomery Community College, Rockville*  
Ena Salter, *State College of Florida*  
Carole Shapero, *Oakton Community College*  
Janet Sibol, *Hillsborough Community College*  
Anne Smallen, *Mohawk Valley Community College*  
Mike Stack, *South Suburban College*  
Barbara Stoner, *Reading Area Community College*  
Jennifer Strehler, *Oakton Community College*  
Ellen Stutes, *Louisiana State University Eunice*  
Tanomo Taguchi, *Fullerton College*  
Sam Tinsley, *Richland College*  
Linda Tucker, *Rose State College*  
MaryAnn Tuerk, *Elgin Community College*  
Gwen Turbeville, *J. Sargeant Reynolds Community College*  
Walter Wang, *Baruch College*  
Leigh Ann Wheeler, *Greenville Technical Community College*  
Jenny Wilson, *Tyler Junior College*  
Valerie Wright, *Central Piedmont Community College*

A special thank you to those students who participated in our design review: Katherine Browne, Mike Bulfin, Nancy Canipe, Ashley Carpenter, Jeff Chojnachi, Roxanne Davis, Mike Dieter, Amy Dombrowski, Kay Herring, Todd Jaycox, Kaleena Levan, Matt Montgomery, Tony Plese, Abigail Polkinghorn, Harley Price, Eli Robinson, Avery Rosen, Robyn Schott, Cynthia Thomas, and Sherry Ward.

*Elayn Martin-Gay*

## About the Author

Elayn Martin-Gay has taught mathematics at the University of New Orleans for more than 25 years. Her numerous teaching awards include the local University Alumni Association's Award for Excellence in Teaching, and Outstanding Developmental Educator at University of New Orleans, presented by the Louisiana Association of Developmental Educators.

Prior to writing textbooks, Elayn Martin-Gay developed an acclaimed series of lecture videos to support developmental mathematics students in their quest for success. These highly successful videos originally served as the foundation material for her texts. Today, the videos are specific to each book in the Martin-Gay series. The author has also created Chapter Test Prep Videos to help students during their most “teachable moment”—as they prepare for a test—along with Instructor-to-Instructor videos that provide teaching tips, hints, and suggestions for each developmental mathematics course, including basic mathematics, prealgebra, beginning algebra, and intermediate algebra. Her most recent innovations are the AlgebraPrep Apps for the iPhone and iPod Touch. These Apps embrace the different learning styles, schedules, and paces of students and provide them with quality math tutoring.

Elayn is the author of 12 published textbooks as well as interactive multimedia mathematics, all specializing in developmental mathematics courses. She has participated as an author across the broadest range of educational materials: textbooks, videos, tutorial software, and courseware. This provides the opportunity of various combinations for an integrated teaching and learning package that offers great consistency for the student.

# Applications Index

## A

### Animals

- altitude of seagull in flight over time, 164
- baby gorillas born in four years, 650
- bear population decrease, 597
- bison population growth, 564
- condor population growth, 598
- cranes born each year in aviary, 668
- diagonal divider in fish tank, 452
- dietary needs of lab rabbits, 232
- dimensions of holding pen for cattle, 493, 625
- dog pen size and capacity, 114, 493
- drug dosage for dogs, 143
- gallons of water drunk by camel over time, 388
- learning curve for chimpanzees, 591
- mosquito population growth, 560, 580
- opossums killed each month on highway, 652
- otters born each year, 652
- population size estimates, 588
- prairie dog and wood duck population growth, 599
- rat population growth, 564
- sparrow species extinction, 639
- spotted owl population decline, 652
- time for dog to eat 50-pound bag of dog food, 503
- traveling speed of black mamba snake, 389
- traveling speed of tortoise, 389
- walking speed of camel, 388
- weevils/mosquitoes killed during insecticide spraying, 659, 668
- western pine beetle infestation growth, 667
- wolf population growth, 591

### Astronomy

- escape velocities for Earth and moon, 418
- launch rates of two rockets, 389
- length of Clarke belt, 75
- planetary eccentricities, 618
- planet distances from the sun, 76
- planet's orbit about the sun, 618–619
- surface area of the moon, 454
- time for rocket to return to ground, 317–318, 491
- weight of object above Earth, 397
- weight of object on Jupiter, 195

### Automotive/motor vehicles

- car depreciation, 197
- car rental plans/costs, 86, 112, 151, 196, 232
- car sales predictions, 659
- daily supply of gasoline in U.S., 494
- Ford vehicle sales worldwide, 114
- maximum safe velocity for car on curve, 471
- minivan rental costs, 196
- predicting future sales of autos, 326
- skidding distance of car, 454
- speed limit detection on highways, 397
- vehicle fatalities, 231

### Aviation

- aircraft carrier deck lengths, 230
- airport arrivals and departures, 58, 67
- cost to operate aircraft, 15
- distance traveled by aircraft, 15
- flight speed of Amelia Earhart's solo, 75
- money spent by Boeing on research & development, 143
- number of seats for aircraft, 66
- passenger traffic volume at airport, 532
- slope of aircraft climb after takeoff, 163
- space shuttle's tank volume, 75
- speed of airplane compared to vehicle on ground, 388, 405
- speed of airplane in still air, 230, 231, 389
- speeds of two airplanes traveling in opposite directions, 633
- takeoff weight of small aircraft, 86
- wind speed, 230, 231

## B

### Business

- annual income for women with bachelor's degree, 163
- average price of new home, 174
- break-even calculations, 68, 112, 213, 227–228, 232, 249, 251
- car sales predictions, 659
- cheese production in U.S., 101, 282, 559
- cost to operate aircraft, 15
- daily cost to operate a small business, 456
- demand function, 484, 625
- diamond production prediction, 142
- earnings during first four years of business, 659, 668
- employee number decreases, 564
- fax-sending charges, 659
- floor space needed for displays, 15
- hours required for one person working alone, 388, 405, 498–499, 503, 505, 531, 533
- hours required for two/three persons working together, 384–385, 388, 389, 402–403, 405, 406, 534, 634
- IBM employees worldwide, 174
- income with commission, 83, 471
- job growth and decline, 66, 163, 231–232
- labor estimate for two persons working together, 389
- machinery rental costs, 151
- manufacturing costs and numbers produced, 28, 150–151, 232, 280, 323, 343, 378–379, 397, 403, 527
- manufacturing time, 150, 188, 398
- markdown, 565
- maximum profit, 527
- McDonald's restaurants worldwide, 174
- minimum hourly wage, 127
- monthly salary vs. products sold, 121–122
- online shopping, 65, 559
- original price after decrease, 60–61, 669
- potential annual salaries, 643
- predicting future sales, 326
- price before tax, 66, 669
- price of each item sold, 231, 232, 408
- pricing and daily sales, 174
- profit, 280, 527
- profit margin, 372
- real estate sales, 168–169
- real estate values over time, 197, 647
- reliability of manufactured items, 599
- rental fees, 659, 668
- restaurant industry employment, 65
- restaurant sales, 164, 281
- retail revenues from Internet shopping, 559
- revenue, 232, 280, 346
- salary after raise, 66, 659, 667
- salary comparison, 668
- salary payment arrangements, 232, 647, 652, 659, 667, 668
- straight-line depreciation, 127
- supply and demand, 213
- time budgeting at work, 244
- time spent on email at work, 65
- value of imports per person in U.S., 269
- weekly earnings in selected job categories, 233
- workforce size before layoffs, 66
- working rate of two/three machines together, 389

## C

### Chemistry and physics

- atmospheric pressure and height, 560
- carbon dioxide concentration in atmosphere, 559
- current in electric circuit, 397

- escape velocity rates, 418
- exponential decay rates, 564
- falling distance of object in pull of gravity, 455
- force exerted by pulling on tree stump, 455
- half-life of decaying materials, 563, 565, 573, 647
- light intensity, 397, 398
- mass of water in lake, 269
- methane emissions in U.S., 527–528
- percent of light passing through glass, 557
- percent of radioactive material, 557
- period of pendulum, 455, 647, 652, 657, 667, 669
- pH of lemonade, 573
- pressure and temperature of gas, 397
- pressure and volume of gas, 393–394, 405
- radiation intensity reduction through lead shield, 597
- radioactive decay rates, 559, 564, 652, 668
- solution mixtures, 225–227, 230, 232, 250, 251, 334
- speed and pitch of sounds traveling, 361, 390
- spring stretching distances, 391–392
- temperature at which glass becomes liquid, 87
- temperature at which stibnite melts, 87
- weight of ball from radius, 397
- weight supported by circular column, 395–396, 398

## D

### Demographics and populations

- annual income for women with bachelor's degree, 163
- life expectancy at birth for females in U.S., 45, 163
- money spent by tourists in selected states, 114
- number of college students in U.S., 296, 401
- passenger traffic volume at airport, 532
- people age 85 or older in U.S., 156–157
- pollution generated by a population, 397
- population decrease/increase, 66, 561–562, 564, 591, 592, 594, 597, 598–599, 669
- population density, 269
- population estimation, 29
- populations of selected cities, 58, 67
- predicted decline of selected jobs, 66, 231–232
- predicted growth of selected jobs, 66, 163
- registered nurses in U.S., 114, 174
- state and federal prison inmates of selected ages, 378
- tourist predictions for selected countries, 113
- value of imports per person in U.S., 269
- vehicle fatalities, 231

## E

### Education

- American students studying abroad, 559
- annual income for women with bachelor's degree, 163
- beginning salaries with bachelor's degree, 87
- college enrollment for each of five years, 639
- earnings with associate's degree, 112
- grant donations payments, 655
- hours spent studying and working per week, 188
- learning curves, 591
- number of college students in U.S., 296, 401, 494
- room and board total for 30 days, 659
- SAT scores in math, 65
- student enrollments at universities, 231
- students taking ACT assessment, 234
- students taking at least one online course, 142
- study abroad host countries, 230–231
- summer school enrollment decreases, 564
- test scores, 62, 86, 96, 199, 407
- total and online enrollments, 136–138
- tuition and fees, 151



**Electronics and computers**

- adult blogging percentage, 231
- cellular telephone users/subscriptions in U.S., 425, 559
- computer/television assembly times, 659, 668
- current in electric circuit, 397
- digital music purchases, 406
- fax-sending charges, 659
- Internet penetration rates, 67
- mp3-capable phone ownership prediction, 406
- rental fees for computers, 659
- resistors wired in parallel, 390
- stereo speaker wire lengths, 323
- supporting cable wire length, 323, 451–452, 454
- Wi-Fi-enabled cell phone use growth, 66, 494, 527
- wireless and text messages sent/received, 234, 520

**Energy**

- electricity generated by wind and geothermal sources, 240
- horsepower and boat speeds, 399
- horsepower transmitted to a shaft, 398
- light bulb hours compared, 67
- number of homes heated by electricity, 383–384
- number of homes heated by fuel oil, 384
- stereo speaker wire length, 323
- supporting cable wire length, 323
- wind speed and its force on a sail, 398

**F****Finance**

- allowance given to a child, 639
- bankruptcy petitions filed, 233
- checking account balance, 463–464
- compound interest, 73, 76, 112, 114, 480–481, 483, 556, 560, 585–586, 590, 591, 596–599
- final loan payment amount, 583, 670
- gold prices, 45
- interest rates, 75, 250, 480–481, 531, 670
- investment doubling, 589, 591, 670
- numbers of new customers at bank, 659
- savings account deposits and balances, 71, 73, 74, 76, 296, 333, 560, 659
- savings needed annually to purchase car, 112
- savings schedule each month, 667

**Food and nutrition**

- applesauce profits, 174
- beef consumption in U.S., 143
- bottled water and soft drink consumption in U.S., 214
- calories in food, 76
- cheddar cheese consumption in U.S., 231
- cheese production in U.S., 101, 282, 559
- food mixtures, 230, 231, 250, 251
- percent of radioactive material in milk, 557
- pH of lemonade, 573
- red meat and poultry consumption in U.S., 222–223
- wedding cake size to serve guests, 324
- whole milk consumption, 87

**G****Geography and geology**

- atmospheric pressures above sea level, 591
- cost to remove pollutants from bayou, 346
- earthquake magnitude, 582, 585
- earthquakes in U.S., 64
- elevation calculations, 29, 44
- gas well depth, 44
- Mauna Kea volcano elevation, 29
- radius of Pacific Ocean Hole 504B, 75
- surface area of Mount Vesuvius before eruption, 434
- tornadoes in U.S., 65

**Geometry**

- angle measurements, 67, 228–229, 232, 233, 251, 252, 334, 407, 463
- area and perimeter of geometric shapes, 439–440
- area of a circle, 28, 142
- area of a parallelogram, 7, 269
- area of a rectangle, 15
- area of a square, 74, 355
- area of a trapezoid, 70

- area of a triangle, 7, 455
- area of geometric figures, 143, 295
- area of metal washer, 310
- circumference and volume of world's largest globe, 75
- circumference of a circle, 44
- complementary angles, 66, 68
- diagonal lengths, 484, 489–490, 492–493, 505
- dimensions from area, 484, 632
- dimensions of rectangle, 62, 108–109, 112, 250, 324, 331, 404, 493, 527, 625, 632
- Ferris wheel radius, 611
- golden ratio value, 493
- height and width of bridge arch, 633
- maximum area of rectangle, 527
- metric conversions, 268–269
- original dimensions from area increase, 112
- original dimensions from volume, 503
- perimeter of a rectangle, 28, 68, 493
- perimeters of geometric figures, 143, 355, 439, 624
- Pythagorean theorem, 450–451
- radius from area, 484, 503
- radius of a zorb, 434
- radius of cylinder from volume and length, 75
- Sarsen Circle radius and circumference, 610–611
- side lengths from perimeters, 67, 68, 232, 250, 251, 371
- side lengths of polygon, 232
- side lengths of triangles, 61–62, 67, 232, 252, 323, 484, 493, 531
- Singapore Flyer radius, 611
- supplementary angles, 66, 68
- surface area of a box, 280, 296, 675, 676–677
- surface area of a cone, 434, 676
- surface area of a cylindrical shell, 331, 394, 400
- surface area of a sphere, 405, 676
- triangle base and height calculations, 74, 493
- volume of a box, 675, 676
- volume of a cone, 398, 676–677
- volume of a cube, 142, 269, 676–677
- volume of a cylinder, 74, 113, 290, 331, 399, 676
- volume of a cylinder with hemisphere at each end, 75
- volume of a pyramid, 676–677
- volume of a rectangle, 677
- volume of a solid, 310
- volume of a sphere, 74–75, 676–677
- volume of box from height, 304
- width of box from volume, 371

**Government and military**

- acres of land not federally owned, 64
- aircraft carrier deck lengths, 230
- federal government income and expenditures, 214
- male marine personnel, 388
- women in Coast Guard, 388

**H****Home improvement**

- board lengths, 371
- connecting pipe length, 470
- dimensions of a room, 484
- dimensions of carpet, 331
- distance across a pond/lake, 470, 612
- fencing needed, 63–64
- floor plan dimensions, 64
- garden dimensions, 324
- hours required for two persons to work together, 406, 534, 634
- ladder length needed, 454
- paint needed, 74, 333
- pitch of roof, 163
- radius of circular sprinkler from area of garden, 503
- sewer pipe slope, 165
- shed floor dimensions, 324
- single-family housing starts, 95
- strawberry plants in garden after five years, 650
- tiles needed for room, 74, 112
- trees/shrubs planted in each row, 651, 669
- weight supported by rectangular beam, 398
- width of border, 323–324

**M****Medicine and health**

- bacteria culture population growth, 639, 645, 652
- basal metabolic rate of a human, 425
- body-mass index and weight/height of human, 389–390
- body surface area of a human, 418
- children's weight estimations, 591
- cigarette consumption, 68, 83–84, 87, 407
- cycle exercise riding times each week, 647
- drug dosage for dogs, 143
- flu epidemic growth, 591
- fungus culture doubling growth, 652
- height of female given length of femur/tibia, 143
- infectious disease doubling growth, 639
- IQ scores and nonsense syllables repeated, 455
- registered nurses in U.S., 114, 174
- virus culture size growth, 647
- vitamin A daily requirements, 495
- volume of vitamin capsule, 75
- yeast culture doubling growth, 667, 668

**Miscellaneous**

- allowance given to a child, 639
- building heights, 68
- cans in each row of triangular display, 647, 667
- charity donations for youth center, 656
- coin calculations, 63, 250
- connecting pipe length, 470
- consecutive integers calculations, 62–63, 65, 67, 112, 199, 318–319, 323, 405
- dimensions of security keypad, 625
- distance across a pond/lake, 470, 612
- elevator weight limits, 86
- emptying/filling rates for tank, 389, 405, 503
- filling rate for goldfish pond, 388, 502
- folded sheet of paper thickness, 667
- laundry cost comparisons, 112
- morning/evening newspaper printings, 251
- motel rooms of each kind occupied, 251
- parking costs, 86
- patents granted by Patent Office, 296, 401
- picture frames bought of each size, 231
- postal charges per ounce, 86
- rolls of stacked carpet, 654
- rotating flywheel revolutions, 659
- shelf space needed, 15
- supporting cable for pole/tower, 323, 451–452, 454
- telephone billing plans, 87
- unknown number calculations, 29, 59, 64, 112, 223–224, 230–232, 248, 250–251, 331, 334, 382, 387–389, 405–406, 503, 527, 531, 532, 625
- ZIP codes, 65

**R****Recreation and entertainment**

- attendance at Disney theme parks, 240
- average speeds during bicycle race, 504
- Cosmo Clock 21 Ferris wheel radius, 611
- cycle exercise riding times each week, 647
- cycling rate during each portion of trip, 389
- distance of parachuting free fall, 659
- DVD rental demand and fees, 434
- Ferris wheel radius, 611
- Frisbee sales, 174
- gambling bet losses, 659
- ice blocks needed for stacking, 654
- jogging and biking speeds during workout, 502
- jogging distances and rates, 389, 502
- movie theater admissions in U.S., 164
- movie viewing rates, 389
- pool scores, 659
- predicting price of Disney World one-day pass, 156
- running speeds during each part of the run, 505
- Singapore Flyer radius, 611
- surfers in each row of human pyramid, 652
- theater attendance costs, 46
- theater seats in each row, 639, 647, 667, 668
- tickets sold of each type, 231

top grossing movies rated PG-13, 389  
 tournament players remaining at finish,  
 562–563, 597  
 walking/jogging speeds, 405

**S****Sports**

average speeds during bicycle race, 504  
 baseball earned run averages, 361  
 baseball games won and team payrolls, 198  
 baseball team wins, 67  
 basketball free throws and field goals, 232–233  
 bouncing heights of racquetball, 667  
 cycling time/speeds, 72, 389  
 golf tournament players remaining at finish,  
 562–563  
 number of stadium/grandstand seats, 66, 67  
 Olympic medals won, 67  
 payrolls for sports teams, 67, 198  
 score needed to receive silver medal, 112  
 speed-skating times, 86  
 women's participation in sports, 230

**T****Temperature and weather**

atmospheric pressure and height, 560  
 Celsius/Fahrenheit conversions, 25–26, 28, 87,  
 96, 112  
 distance from lightning flash, 15  
 high/low temperatures, 74, 494  
 monthly rainfall, 234

**Time and distance**

bouncing heights of ball, 647, 659, 667  
 computer assembly times, 659  
 cycle exercise riding times each week, 647  
 cycling rate during each portion of trip, 389  
 distance across a pond, 470  
 distance an olive falls in a vacuum, 667  
 distance from lightning flash, 15  
 distance of parachuting free fall, 659, 669  
 distance saved, 489–490, 492–493, 533  
 distance seen from a height, 397, 455

distance traveled by aircraft, 15  
 distance traveled by bouncing ball, 657, 668  
 distance traveled by pendulum, 657, 667, 669  
 distance traveled by ships in opposite  
 directions, 531  
 driving distance, 112  
 driving speed, 113, 471, 499–500  
 driving time, 75  
 falling distance of object in pull of gravity, 455  
 height/time of dropped/thrown object, 174,  
 272–273, 280, 296, 304, 324, 332–333, 401,  
 406, 483–484, 490–491, 493–494, 524–527,  
 531–533, 639, 667, 670  
 hours required for one person working alone,  
 388, 405, 498–499, 503, 505, 531, 533  
 hours required for two/three persons working  
 together, 384–385, 388, 389, 402–403, 405,  
 406, 534, 634  
 jogging distances and rates, 389  
 original driving speed and return trip  
 speed, 502  
 original driving speed and speed during  
 rainfall, 502  
 planet distances from the sun, 76  
 rate of retrieving drill from deepest man-made  
 hole, 75  
 rates of conveyor belts, 389  
 round-trip driving time, 74  
 rowing speed in still water, 230  
 rowing speeds against and with the current, 389  
 skidding distance of car, 454  
 speed limit detection on highways, 397  
 speed of airplane in still air, 230, 231, 389  
 speed of boat in still water, 388  
 speed of current, 230, 385–386, 388, 405, 600  
 speed-skating times, 86  
 speeds of two trains traveling parallel, 405  
 speeds of vehicles traveling in opposite  
 directions, 224–225, 250, 388, 633  
 spring stretching distances, 391–392  
 time for dog to eat 50-pound bag  
 of dog food, 503

time for rocket to return to ground, 317–318  
 time for two printing presses to complete  
 a job, 388  
 walking speed of camel, 388  
 wind speed, 230, 231, 387  
 wind speed and its force on a sail, 398

**Transportation**

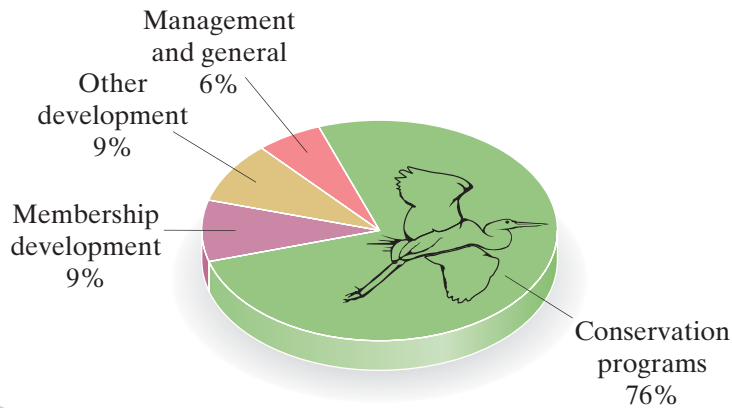
airport arrivals and departures, 58, 67  
 driving distance, 112  
 driving speed, 113, 471, 499–500  
 driving time, 75  
 height and width of bridge arch, 633  
 maximum safe velocity for car on curve, 471  
 original driving speed and return trip  
 speed, 502  
 original driving speed and speed during  
 rainfall, 502  
 parking costs, 86  
 round-trip driving time, 74  
 skidding distance of car, 454  
 speed of airplane compared to vehicle on  
 ground, 388, 405  
 speed of boat in still water, 388  
 speed of truck compared to airplane, 388  
 speed of two trains traveling parallel, 405  
 truck speeds in mountains and flatlands, 389  
 vehicle fatalities, 231

**W****World records**

busiest airport, 532  
 deepest gas well, 44  
 deepest hole in ocean floor, 75  
 deepest man-made hole, 75  
 heaviest door, 493  
 highest and lowest points of land, 29  
 highest bridge, 272–273  
 largest globe, 75  
 largest natural bridge, 273  
 longest cross-sea bridge, 500  
 tallest building, 484  
 tallest dam, 484

# Real Numbers and Algebraic Expressions

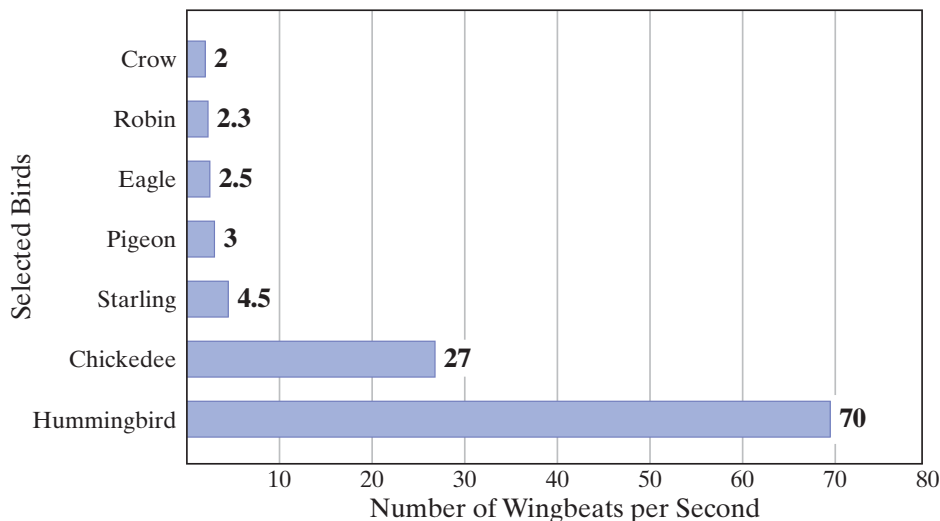
**National Audubon Society Expenses for a Recent Year**



The National Audubon Society is a U.S. nonprofit organization dedicated to conservation. It is named in honor of John James Audubon, a Franco-American naturalist who painted and described the birds of North America in his famous book *Birds of America* published in sections between 1827 and 1838.

The Audubon Society is over a century old and funds conservation programs focusing on birds.

The bar graph below shows the differing wingbeats per second for selected birds. In the Chapter 1 Review, Exercises 3 and 4, we study the hummingbird wingbeats per second further.



Source: National Audubon Society website

- 1.1** Tips for Success in Mathematics
- 1.2** Algebraic Expressions and Sets of Numbers
- 1.3** Operations on Real Numbers and Order of Operations  
Integrated Review—Algebraic Expressions and Operations on Whole Numbers
- 1.4** Properties of Real Numbers and Algebraic Expressions

In arithmetic, we add, subtract, multiply, divide, raise to powers, and take roots of numbers. In algebra, we add, subtract, multiply, divide, raise to powers, and take roots of variables. Letters, such as  $x$ , that represent numbers are called **variables**. Understanding these algebraic expressions depends on your understanding of arithmetic expressions. This chapter reviews the arithmetic operations on real numbers and the corresponding algebraic expressions.

## 1.1 Tips for Success in Mathematics

### OBJECTIVES

- 1 Get Ready for This Course.
- 2 Understand Some General Tips for Success.
- 3 Understand How to Use This Text.
- 4 Get Help as Soon as You Need It.
- 5 Learn How to Prepare for and Take an Exam.
- 6 Develop Good Time Management.

#### Helpful Hint

**MyMathLab**® and **MathXL**® If you are doing your homework online, you can work and rework those exercises that you struggle with until you master them. Try working through all the assigned exercises twice before the due date.

#### Helpful Hint

**MyMathLab**® and **MathXL**® If you are completing your homework online, it's important to work each exercise on paper before submitting the answer. That way, you can check your work and follow your steps to find and correct any mistakes.

Before reading this section, remember that your instructor is your best source of information. Please see your instructor for any additional help or information.

#### OBJECTIVE

### 1 Getting Ready for This Course

Now that you have decided to take this course, remember that a *positive attitude* will make all the difference in the world. Your belief that you can succeed is just as important as your commitment to this course. Make sure you are ready for this course by having the time and positive attitude that it takes to succeed.

Next, make sure that you have scheduled your math course at a time that will give you the best chance for success. For example, if you are also working, you may want to check with your employer to make sure that your work hours will not conflict with your course schedule.

On the day of your first class period, double-check your schedule and allow yourself extra time to arrive on time in case of traffic problems or difficulty locating your classroom. Make sure that you bring at least your textbook, paper, and a writing instrument. Are you required to have a lab manual, graph paper, calculator, or some other supplies besides this text? If so, also bring this material with you.

#### OBJECTIVE

### 2 General Tips for Success

Below are some general tips that will increase your chance for success in a mathematics class. Many of these tips will also help you in other courses you may be taking.

*Exchange names and phone numbers or email addresses* with at least one other person in class. This contact person can be a great help if you miss an assignment or want to discuss math concepts or exercises that you find difficult.

*Choose to attend all class periods.* If possible, sit near the front of the classroom. This way, you will see and hear the presentation better. It may also be easier for you to participate in classroom activities.

*Do your homework.* You've probably heard the phrase "practice makes perfect" in relation to music and sports. It also applies to mathematics. You will find that the more time you spend solving mathematics exercises, the easier the process becomes. Be sure to schedule enough time to complete your assignments before the due date assigned by your instructor.

*Check your work.* Review the steps you made while working a problem. Learn to check your answers in the original problems. You may also compare your answers with the "Answers to Selected Exercises" section in the back of the book. If you have made a mistake, try to figure out what went wrong. Then correct your mistake. If you can't find what went wrong, don't erase your work or throw it away. Bring your work to your instructor, a tutor in a math lab, or a classmate. It is easier for someone to find where you had trouble if he or she looks at your original work.

*Learn from your mistakes and be patient with yourself.* Everyone, even your instructor, makes mistakes. (That definitely includes me—Elayn Martin-Gay.) Use your errors to learn and to become a better math student. The key is finding and understanding your errors.

Was your mistake a careless one, or did you make it because you can't read your own math writing? If so, try to work more slowly or write more neatly and make a conscious effort to check your work carefully.

Did you make a mistake because you don't understand a concept? Take the time to review the concept or ask questions to understand it better.

Did you skip too many steps? Skipping steps or trying to do too many steps mentally may lead to preventable mistakes.

*Know how to get help if you need it.* It's all right to ask for help. In fact, it's a good idea to ask for help whenever there is something that you don't understand.

Make sure you know when your instructor has office hours and how to find his or her office. Find out whether math tutoring services are available on your campus. Check on the hours, location, and requirements of the tutoring service.

**Helpful Hint**

**MyMathLab®** and **MathXL®** When assignments are turned in online, keep a hard copy of your complete written work. You will need to refer to your written work to be able to ask questions and to study for tests later.

**Helpful Hint**

**MyMathLab®** and **MathXL®** Be aware of assignments and due dates set by your instructor. Don't wait until the last minute to submit work online. Allow 6–8 hours before the deadline in case you have technology trouble.

**Helpful Hint**

**MyMathLab®** In MyMathLab, you have access to the following video resources:

- Lecture Videos for each section
- Chapter Test Prep Videos

Use these videos provided by the author to prepare for class, review, and study for tests.

*Organize your class materials*, including homework assignments, graded quizzes and tests, and notes from your class or lab. All of these items will make valuable references throughout your course and when studying for upcoming tests and the final exam. Make sure that you can locate these materials when you need them.





*Read your textbook before class.* Reading a mathematics textbook is unlike reading a novel or a newspaper. Your pace will be much slower. It is helpful to have paper and a pencil with you when you read. Try to work out examples on your own as you encounter them in your text. You should also write down any questions that you want to ask in class. When you read a mathematics textbook, sometimes some of the information in a section will be unclear. But after you hear a lecture or watch a lecture video on that section, you will understand it much more easily than if you had not read your text beforehand.

*Don't be afraid to ask questions.* You are not the only person in class with questions. Other students are normally grateful that someone has spoken up.

*Turn in assignments on time.* This way you can be sure that you will not lose points for being late. Show every step of a problem and be neat and organized. Also be sure that you understand which problems are assigned for homework. If allowed, you can always double-check the assignment with another student in your class.

**OBJECTIVE****3 Using This Text**

Many helpful resources are available to you. It is important to become familiar with and use these resources. They should increase your chances for success in this course.

- *Practice Exercises.* Each example in every section has a parallel Practice exercise. As you read a section, try each Practice exercise after you've finished the corresponding example. This “learn-by-doing” approach will help you grasp ideas before you move on to other concepts. Answers are at the back of the text.
- *Chapter Test Prep Videos.* These videos provide solutions to all of the Chapter Test exercises worked out by the author. This supplement is very helpful before a test or exam.
- *Interactive DVD Lecture Series.* Exercises marked with a  are fully worked out by the author on the DVDs. The lecture series provides approximately 20 minutes of instruction per section.
- *Symbols at the Beginning of an Exercise Set.* If you need help with a particular section, the symbols listed at the beginning of each exercise set will remind you of the numerous supplements available.
- *Examples.* The main section of exercises in each exercise set is referenced by an example(s). There is also often a section of exercises entitled “Mixed Practice,” which combines exercises from multiple objectives or sections. These are mixed exercises written to prepare you for your next exam. Use all of this referencing if you have trouble completing an assignment from the exercise set.
- *Icons (Symbols).* Make sure that you understand the meaning of the icons that are beside many exercises.  tells you that the corresponding exercise may be viewed on the video segment that corresponds to that section.  tells you that this exercise is a writing exercise in which you should answer in complete sentences.  tells you that the exercise involves geometry.
- *Integrated Reviews.* Found in the middle of each chapter, these reviews offer you a chance to practice—in one place—the many concepts that you have learned separately over several sections.
- *End-of-Chapter Opportunities.* There are many opportunities at the end of each chapter to help you understand the concepts of the chapter.

**Vocabulary Checks** contain key vocabulary terms introduced in the chapter.

**Chapter Highlights** contain chapter summaries and examples.

**Chapter Reviews** contain review problems. The first part is organized section by section and the second part contains a set of mixed exercises.

**Chapter Tests** are sample tests to help you prepare for an exam. The Chapter Test Prep Videos, found in this text, contain all the Chapter Test exercises worked by the author.

**Cumulative Reviews** are reviews consisting of material from the beginning of the book to the end of that particular chapter.

- *Student Resources in Your Textbook.* You will find a **Student Resources** section at the back of this textbook. It contains the following to help you study and prepare for tests:

**Study Skill Builders** contain study skills advice. To increase your chance for success in the course, read these study tips and answer the questions.

**Bigger Picture–Study Guide Outline** provides you with a study guide outline of the course, with examples.

**Practice Final** provides you with a Practice Final Exam to help you prepare for a final. The video solutions to each question are provided in the Interactive DVD Lecture Series and within MyMathLab®.

- *Resources to Check Your Work.* The **Answers to Selected Exercises** section provides answers to all odd-numbered section exercises and all chapter test exercises.

## OBJECTIVE

4 Getting Help  Helpful Hint

MyMathLab® and MathXL®

- Use the **Help Me Solve This** button to get step-by-step help for the exercise you are working. You will need to work an additional exercise of the same type before you can get credit for having worked it correctly.
- Use the **Video** button to view a video clip of the author working a similar exercise.

If you have trouble completing assignments or understanding the mathematics, get help as soon as you need it! This tip is presented as an objective on its own because it is so important. In mathematics, usually the material presented in one section builds on your understanding of the previous section. This means that if you don't understand the concepts covered during a class period, there is a good chance that you will not understand the concepts covered during the next class period. If this happens to you, get help as soon as you can.

Where can you get help? Many suggestions have been made in this section on where to get help, and now it is up to you to get it. Try your instructor, a tutoring center, or a math lab, or you may want to form a study group with fellow classmates. If you do decide to see your instructor or go to a tutoring center, make sure that you have a neat notebook and are ready with your questions.

## OBJECTIVE

5 Preparing for and Taking an Exam  Helpful Hint

MyMathLab® and MathXL®

Review your written work for previous assignments. Then, go back and rework previous assignments. Open a previous assignment, and click **Similar Exercise** to generate new exercises. Rework the exercises until you fully understand them and can work them without help features.

Make sure that you allow yourself plenty of time to prepare for a test. If you think that you are a little “math anxious,” it may be that you are not preparing for a test in a way that will ensure success. The way that you prepare for a test in mathematics is important. To prepare for a test:

1. Review your previous homework assignments.
2. Review any notes from class and section-level quizzes you have taken. (If this is a final exam, also review chapter tests you have taken.)
3. Review concepts and definitions by reading the Chapter Highlights at the end of each chapter.
4. Practice working out exercises by completing the Chapter Review found at the end of each chapter. (If this is a final exam, go through a Cumulative Review. There is one found at the end of each chapter except Chapter 1. Choose the review found at the end of the latest chapter that you have covered in your course.) *Don't stop here!*
5. It is important to place yourself in conditions similar to test conditions to find out how you will perform. In other words, as soon as you feel that you know the material, get a few blank sheets of paper and take a sample test. A Chapter Test is available at the end of each chapter, or you can work selected problems from the Chapter Review. Your instructor may also provide you with a review sheet. During this sample test, do not use your notes or your textbook. Then check your sample test. If you are not satisfied with the results, study the areas that you are weak in and try again.
6. On the day of the test, allow yourself plenty of time to arrive at where you will be taking your exam.

When taking your test:

1. Read the directions on the test carefully.
2. Read each problem carefully as you take the test. Make sure that you answer the question asked.
3. Watch your time and pace yourself so that you can attempt each problem on your test.
4. If you have time, check your work and answers.
5. Do not turn your test in early. If you have extra time, spend it double-checking your work.

OBJECTIVE

## 6 Managing Your Time

As a college student, you know the demands that classes, homework, work, and family place on your time. Some days you probably wonder how you'll ever get everything done. One key to managing your time is developing a schedule. Here are some hints for making a schedule:




1. Make a list of all of your weekly commitments for the term. Include classes, work, regular meetings, extracurricular activities, etc. You may also find it helpful to list such things as laundry, regular workouts, grocery shopping, etc.
2. Next, estimate the time needed for each item on the list. Also make a note of how often you will need to do each item. Don't forget to include time estimates for the reading, studying, and homework you do outside of your classes. You may want to ask your instructor for help estimating the time needed.
3. In the exercise set that follows, you are asked to block out a typical week on the schedule grid given. Start with items with fixed time slots like classes and work.
4. Next, include the items on your list with flexible time slots. Think carefully about how best to schedule items such as study time.
5. Don't fill up every time slot on the schedule. Remember that you need to allow time for eating, sleeping, and relaxing! You should also allow a little extra time in case some items take longer than planned.
6. If you find that your weekly schedule is too full for you to handle, you may need to make some changes in your workload, classload, or other areas of your life. You may want to talk to your advisor, manager or supervisor at work, or someone in your college's academic counseling center for help with such decisions.



## 1.1 Exercise Set

MyMathLab®



1. What is your instructor's name?
2. What are your instructor's office location and office hours?
3. What is the best way to contact your instructor?
4. Do you have the name and contact information of at least one other student in class?
5. Will your instructor allow you to use a calculator in this class?
6. Why is it important that you write step-by-step solutions to homework exercises and keep a hard copy of all work submitted?
7. Is a tutoring service available on campus? If so, what are its hours? What services are available?
8. Have you attempted this course before? If so, write down ways that you might improve your chances of success during this second attempt.
9. List some steps that you can take if you begin having trouble understanding the material or completing an assignment. If you are completing your homework in MyMathLab® and MathXL®, list the resources you can use for help.
10. How many hours of studying does your instructor advise for each hour of instruction?
11. What does the  icon in this text mean?
12. What does the  icon in this text mean?
13. What does the  icon in this text mean?
14. What are Practice exercises?
15. When might be the best time to work a Practice exercise?
16. Where are the answers to Practice exercises?
17. What answers are contained in this text and where are they?
18. What and where are the study skills builders?

19. What and where are Integrated Reviews?
20. How many times is it suggested that you work through the homework exercises in MathXL<sup>®</sup> before the submission deadline?
21. How far in advance of the assigned due date is it suggested that homework be submitted online? Why?
22. Chapter Highlights are found at the end of each chapter. Find the Chapter 1 Highlights and explain how you might use it and how it might be helpful.
23. Chapter Reviews are found at the end of each chapter. Find the Chapter 1 Review and explain how you might use it and how it might be useful.
24. Chapter Tests are found at the end of each chapter. Find the Chapter 1 Test and explain how you might use it and how it might be helpful when preparing for an exam on Chapter 1. Include how the Chapter Test Prep Videos may help. If you are working in MyMathLab<sup>®</sup> and MathXL<sup>®</sup>, how can you use previous homework assignments to study?
25. Read or reread objective 6 and fill out the schedule grid below.

	<i>Monday</i>	<i>Tuesday</i>	<i>Wednesday</i>	<i>Thursday</i>	<i>Friday</i>	<i>Saturday</i>	<i>Sunday</i>
<b>1:00 a.m.</b>							
<b>2:00 a.m.</b>							
<b>3:00 a.m.</b>							
<b>4:00 a.m.</b>							
<b>5:00 a.m.</b>							
<b>6:00 a.m.</b>							
<b>7:00 a.m.</b>							
<b>8:00 a.m.</b>							
<b>9:00 a.m.</b>							
<b>10:00 a.m.</b>							
<b>11:00 a.m.</b>							
<b>12:00 p.m.</b>							
<b>1:00 p.m.</b>							
<b>2:00 p.m.</b>							
<b>3:00 p.m.</b>							
<b>4:00 p.m.</b>							
<b>5:00 p.m.</b>							
<b>6:00 p.m.</b>							
<b>7:00 p.m.</b>							
<b>8:00 p.m.</b>							
<b>9:00 p.m.</b>							
<b>10:00 p.m.</b>							
<b>11:00 p.m.</b>							
<b>Midnight</b>							



## 1.2 Algebraic Expressions and Sets of Numbers

### OBJECTIVES

- 1 Identify and Evaluate Algebraic Expressions. ▶
- 2 Identify Natural Numbers, Whole Numbers, Integers, and Rational and Irrational Real Numbers. ▶
- 3 Find the Absolute Value of a Number. ▶
- 4 Find the Opposite of a Number. ▶
- 5 Write Phrases as Algebraic Expressions. ▶

### OBJECTIVE

#### 1 Evaluating Algebraic Expressions ▶

Recall that letters that represent numbers are called **variables**. An **algebraic expression** (or simply **expression**) is formed by numbers and variables connected by the operations of addition, subtraction, multiplication, division, raising to powers, or taking roots. For example,

$$2x, \quad \frac{x+5}{6}, \quad \sqrt{y} - 1.6, \quad \text{and} \quad z^3$$

are algebraic expressions or, more simply, expressions. (Recall that the expression  $2x$  means  $2 \cdot x$ .)

Algebraic expressions occur often during problem solving. For example, the average cost to own and operate a car in the United States for 2009 was \$0.453 per mile. The expression  $0.453m$  gives the total cost to operate a car annually for  $m$  miles. (Source: AAA)



To find the cost of driving a car for 12,000 miles, for example, we replace the variable  $m$  with 12,000 and perform the indicated operation. This process is called **evaluating** an expression, and the result is called the **value** of the expression for the given replacement value.

#### ▶ Helpful Hint

Recall that  $0.453m$  means  $0.453 \times m$

In our example, when  $m = 12,000$ ,

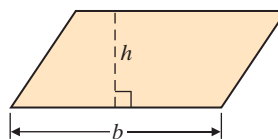
$$0.453m = 0.453(12,000) = 5436$$

Thus, it costs \$5436 to own and operate a car for 12,000 miles of driving.



### EXAMPLE 1 Finding the Area of a Tile

The research department of a flooring company is considering a new flooring design that contains parallelograms. The area of a parallelogram with base  $b$  and height  $h$  is  $bh$ . Find the area of a parallelogram with base 10 centimeters and height 8.2 centimeters.



**Solution** We replace  $b$  with 10 and  $h$  with 8.2 in the algebraic expression  $bh$ .

$$bh = 10 \cdot 8.2 = 82$$

The area is 82 square centimeters □

### PRACTICE

#### 1

The tile edging for a bathroom is in the shape of a triangle. The area of a triangle with base  $b$  and height  $h$  is  $A = \frac{1}{2}bh$ . Find the area of the tile if the base measures 3.5 cm and the height measures 8 cm.

..... ■

Algebraic expressions simplify to different values depending on replacement values. (Order of operations is needed for simplifying many expressions. We fully review this in Section 1.3.)

**EXAMPLE 2** Evaluate:  $3x - y$  when  $x = 15$  and  $y = 4$ .

**Solution** We replace  $x$  with 15 and  $y$  with 4 in the expression.

$$3x - y = 3 \cdot 15 - 4 = 45 - 4 = 41 \quad \square$$

PRACTICE

**2** Evaluate  $2p - q$  when  $p = 17$  and  $q = 3$ .

When evaluating an expression to solve a problem, we often need to think about the kind of number that is appropriate for the solution. For example, if we are asked to determine the maximum number of parking spaces for a parking lot to be constructed, an answer of  $98\frac{1}{10}$  is not appropriate because  $\frac{1}{10}$  of a parking space is not realistic.

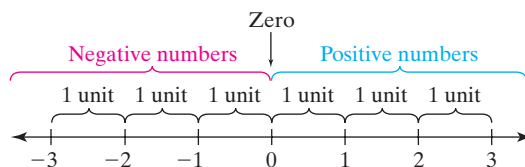
OBJECTIVE

## 2 Identifying Common Sets of Numbers

Let's review some common sets of numbers and their graphs on a number line. To construct a number line, we draw a line and label a point 0 with which we associate the number 0. This point is called the **origin**. Choose a point to the right of 0 and label it 1. The distance from 0 to 1 is called the **unit distance** and can be used to locate more points. The **positive numbers** lie to the right of the origin, and the **negative numbers** lie to the left of the origin. The number 0 is neither positive nor negative.

### Helpful Hint

0 is neither a positive number nor a negative number.



### ✓ CONCEPT CHECK

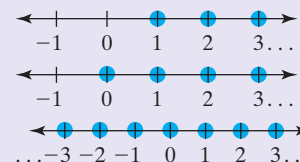
Use the definitions of positive numbers, negative numbers, and zero to describe the meaning of *nonnegative numbers*.

A number is **graphed** on a number line by shading the point on the number line that corresponds to the number. Some common sets of numbers and their graphs include:

**Natural numbers:**  $\{1, 2, 3, \dots\}$

**Whole numbers:**  $\{0, 1, 2, 3, \dots\}$

**Integers:**  $\{\dots, -3, -2, -1, 0, 1, 2, 3, \dots\}$

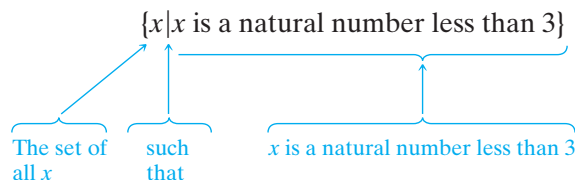


Each listing of three dots,  $\dots$ , is called an **ellipsis** and means to continue in the same pattern.

A **set** is a collection of objects. The objects of a set are called its **members** or **elements**. When the elements of a set are listed, such as those displayed in the box above, the set is written in **roster** form.

Answer to Concept Check:  
a number that is 0 or positive

A set can also be written in **set builder notation**, which describes the members of a set but does not list them. The following set is written in set builder notation.



**Helpful Hint**

Use  $\{ \}$  or  $\emptyset$  to write the empty set.  $\{\emptyset\}$  is **not** the empty set because it has one element:  $\emptyset$ .

This same set written in roster form is  $\{1, 2\}$ .

A set that contains *no* elements is called the **empty set** (or **null set**), symbolized by  $\{ \}$  or  $\emptyset$ . The set

$$\{x \mid x \text{ is a month with 32 days}\} \text{ is } \emptyset \text{ or } \{ \}$$

because no month has 32 days. The set has no elements.

**EXAMPLE 3** Write each set in roster form. (List the elements of each set.)

- a.  $\{x \mid x \text{ is a natural number greater than } 100\}$   
 b.  $\{x \mid x \text{ is a whole number between } 1 \text{ and } 6\}$

**Solution**

- a.  $\{101, 102, 103, \dots\}$       b.  $\{2, 3, 4, 5\}$  □

**PRACTICE**

**3** Write each set in roster form. (List the elements of each set.)

- a.  $\{x \mid x \text{ is a whole number between } 5 \text{ and } 10\}$   
 b.  $\{x \mid x \text{ is a natural number greater than } 40\}$

The symbol  $\in$  denotes that an element is in a particular set. The symbol  $\in$  is read as “is an element of.” For example, the true statement

$$3 \text{ is an element of } \{1, 2, 3, 4, 5\}$$

can be written in symbols as

$$3 \in \{1, 2, 3, 4, 5\}$$

The symbol  $\notin$  is read as “is not an element of.” In symbols, we write the true statement “ $p$  is not an element of  $\{a, 5, g, j, q\}$ ” as

$$p \notin \{a, 5, g, j, q\}$$

**EXAMPLE 4** Determine whether each statement is true or false.

- a.  $3 \in \{x \mid x \text{ is a natural number}\}$       b.  $7 \notin \{1, 2, 3\}$

**Solution**

- a. True, since 3 is a natural number and therefore an element of the set.  
 b. True, since 7 is not an element of the set  $\{1, 2, 3\}$ . □

**PRACTICE**

**4** Determine whether each statement is true or false.

- a.  $7 \in \{x \mid x \text{ is a natural number}\}$       b.  $6 \notin \{1, 3, 5, 7\}$