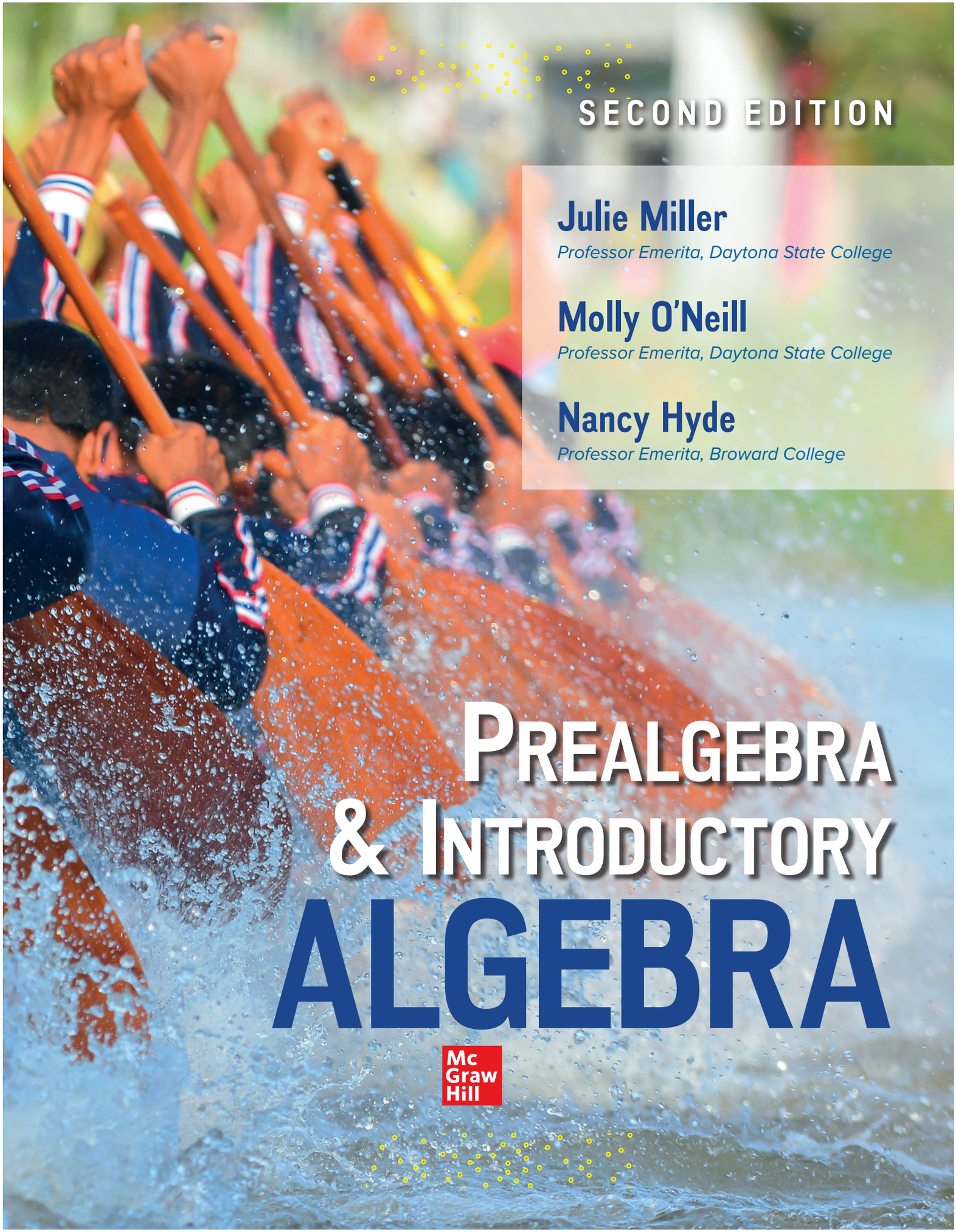

SECOND EDITION

Julie Miller
Professor Emerita, Daytona State College

Molly O'Neill
Professor Emerita, Daytona State College

Nancy Hyde
Professor Emerita, Broward College

PREALGEBRA & INTRODUCTORY ALGEBRA

Mc Graw Hill

PREALGEBRA & INTRODUCTORY ALGEBRA, SECOND EDITION

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Letter from the Authors

Dear Colleagues,

Across the country, Developmental Math courses are in a state of flux, and we as instructors are at the center of it all. As many of our institutions are grappling with the challenges of placement, retention, and graduation rates, we are on the front lines with our students—supporting all of them in their educational journey.

Flexibility—No Matter Your Course Format!

The three of us each teach differently, as do many of our current users. The Miller/O'Neill/Hyde series is designed for successful use in a variety of course formats, both traditional and modern—classroom lecture settings, flipped classrooms, hybrid classes, and online-only classes.

Ease of Instructor Preparation

We've all had to fill in for a colleague, pick up a last-minute section, or find ourselves running across campus to yet a different course. The Miller/O'Neill/Hyde series is carefully designed to support instructors teaching in a variety of different settings and circumstances. Experienced, senior faculty members can draw from a massive library of static and algorithmic content found in ALEKS and Connect Hosted by ALEKS to meticulously build assignments and assessments sharply tailored to individual student needs. Newer instructors and part-time adjunct instructors, on the other hand, will find support through a wide range of digital resources and prebuilt assignments ready to go on Day One. With these tools, instructors with limited time to prepare for class can still facilitate successful student outcomes.

Many instructors want to incorporate discovery-based learning and groupwork into their courses but don't have time to write or find quality materials. We have ready-made Group Activities that are available online. Furthermore, each section of the text has numerous discovery-based activities that we have tested in our own classrooms. These are found in the Student Resource Manual along with other targeted worksheets for additional practice and materials for a student portfolio.

Student Success—Now and in the Future

Too often our math placement tests fail our students, which can lead to frustration, anxiety, and often withdrawal from their education journey. We encourage you to learn more about ALEKS Placement, Preparation, and Learning (ALEKS PPL), which uses adaptive learning technology to place students appropriately. No matter the skills they come in with, the Miller/O'Neill/Hyde series provides resources and support that uniquely position them for success in that course and for their next course. Whether they need a brush-up on their basic skills, ADA supportive materials, or advanced topics to help them cross the bridge to the next level, we've created a support system for them.

We hope you are as excited as we are about the series and the supporting resources and services that accompany it. Please reach out to any of us with any questions or comments you have about our texts.

Julie Miller
julie.miller.math@gmail.com

Molly O'Neill
molly.s.oneill@gmail.com

Nancy Hyde
nhyde@montanasky.com

About the Authors

Photo courtesy of Molly O'Neill

Julie Miller is from Daytona State College, where she taught developmental and upper-level mathematics courses for 20 years. Prior to her work at Daytona State College, she worked as a software engineer for General Electric in the area of flight and radar simulation. Julie earned a Bachelor of Science in Applied Mathematics from Union College in Schenectady, New York, and a Master of Science in Mathematics from the University of Florida. In addition to this textbook, she has authored textbooks for college algebra, trigonometry, and precalculus, as well as several short works of fiction and nonfiction for young readers.

"My father is a medical researcher, and I got hooked on math and science when I was young and would visit his laboratory. I can remember using graph paper to plot data points for his experiments and doing simple calculations. He would then tell me what the peaks and features in the graph meant in the context of his experiment. I think that applications and hands-on experience made math come alive for me, and I'd like to see math come alive for my students."

—Julie Miller

Molly O'Neill is also from Daytona State College, where she taught for 22 years in the School of Mathematics. She has taught a variety of courses from developmental mathematics to calculus. Before she came to Florida, Molly taught as an adjunct instructor at the University of Michigan–Dearborn, Eastern Michigan University, Wayne State University, and Oakland Community College. Molly earned a Bachelor of Science in Mathematics and a Master of Arts and Teaching from Western Michigan University in Kalamazoo, Michigan. Besides this textbook, she has authored several course supplements for college algebra, trigonometry, and precalculus and has reviewed texts for developmental mathematics.

"I differ from many of my colleagues in that math was not always easy for me. But in seventh grade I had a teacher who taught me that if I follow the rules of mathematics, even I could solve math problems. Once I understood this, I enjoyed math to the point of choosing it for my career. I now have the greatest job because I get to do math every day and I have the opportunity to influence my students just as I was influenced. Authoring these texts has given me another avenue to reach even more students."

—Molly O'Neill

Nancy Hyde served as a full-time faculty member of the Mathematics Department at Broward College for 24 years. During this time she taught the full spectrum of courses from developmental math through differential equations. She received a Bachelor of Science in Math Education from Florida State University and a Master's degree in Math Education from Florida Atlantic University. She has conducted workshops and seminars for both students and teachers on the use of technology in the classroom. In addition to this textbook, she has authored a graphing calculator supplement for *College Algebra.*

"I grew up in Brevard County, Florida, where my father worked at Cape Canaveral. I was always excited by mathematics and physics in relation to the space program. As I studied higher levels of mathematics I became more intrigued by its abstract nature and infinite possibilities. It is enjoyable and rewarding to convey this perspective to students while helping them to understand mathematics."

—Nancy Hyde

Dedication

To Our Students

Julie Miller ❧ Molly O'Neill ❧ Nancy Hyde

The Miller/O'Neill/Hyde Developmental Math Series

Julie Miller, Molly O'Neill, and Nancy Hyde originally wrote their developmental math series because students were entering their College Algebra course underprepared. The students were not mathematically mature enough to understand the concepts of math, nor were they fully engaged with the material. The authors began their developmental mathematics offerings with Intermediate Algebra to help bridge that gap. This in turn evolved into several series of textbooks from Prealgebra through Precalculus to help students at all levels before Calculus.

What sets all of the Miller/O'Neill/Hyde series apart is that they address course content through an author-created digital package that maintains a consistent voice and notation throughout the program. This consistency—in videos, PowerPoints, Lecture Notes, Integrated Video and Study Guides, and Group Activities—coupled with the power of ALEKS and Connect Hosted by ALEKS, ensures that students master the skills necessary to be successful in Developmental Math through Precalculus and prepares them for the Calculus sequence.

Developmental Math Series

The Developmental Math series is traditional in approach, delivering a purposeful balance of skills and conceptual development. It places a strong emphasis on conceptual learning to prepare students for success in subsequent courses.

Basic College Mathematics, Third Edition
Prealgebra, Third Edition
Prealgebra & Introductory Algebra, Second Edition
Beginning Algebra, Fifth Edition
Beginning & Intermediate Algebra, Fifth Edition
Intermediate Algebra, Fifth Edition
Developmental Mathematics: Prealgebra, Beginning Algebra, & Intermediate Algebra, First Edition

College Algebra/Precalculus Series

The Precalculus series serves as the bridge from Developmental Math coursework to future courses by emphasizing the skills and concepts needed for Calculus.

College Algebra, Second Edition
College Algebra and Trigonometry, First Edition
Precalculus, First Edition

Acknowledgments

The author team most humbly would like to thank all the people who have contributed to this project and the Miller/O'Neill/Hyde Developmental Math series as a whole.

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To the marketing team, Chad Grall, Noah Evans, and Annie Clark: thank you for your creative ideas in making our books come to life in the market. Thank you as well to Cherie Pye for continuing to drive our long-term content vision through her market development efforts. To the digital content experts, Cynthia Northrup and Brenna Gordon: we are most grateful for your long hours of work and innovation in a world that changes from day to day. And many thanks to the team at ALEKS for creating its spectacular adaptive technology and for overseeing the quality control in Connect Math.

To the production team: Jane Mohr, David Hash, Rachael Hillebrand, Sandy Schnee, and Lorraine Buczek—thank you for making the manuscript beautiful and for keeping the train on the track. You've been amazing. And finally, to Mike Ryan: thank you for supporting our projects for many years and for the confidence you've always shown in us.

Most importantly, we give special thanks to the students and instructors who use our series in their classes.

Julie Miller
Molly O'Neill
Nancy Hyde

Contents

To the Student

Take a deep breath and know that you aren't alone. Your instructor, fellow students, and we, your authors, are here to help you learn and master the material for this course and prepare you for future courses. You may feel like math just isn't your thing, or maybe it's been a long time since you've had a math class—that's okay!

We wrote the text and all the supporting materials with you in mind. Most of our students aren't really sure how to be successful in math, but we can help with that.

As you begin your class, we'd like to offer some specific suggestions:

1. **Attend class.** Arrive on time and be prepared. If your instructor has asked you to read prior to attending class—do it. How often have you sat in class and thought you understood the material, only to get home and realize you don't know how to get started? By reading and trying a couple of Skill Practice exercises, which follow each example, you will be able to ask questions and gain clarification from your instructor when needed.
2. **Be an *active* learner.** Whether you are at lecture, watching an author lecture or exercise video, or are reading the text, pick up a pencil and work out the examples given. Math is learned only by doing; we like to say, "Math is not a spectator sport." If you like a bit more guidance, we encourage you to use the Integrated Video and Study Guide. It was designed to provide structure and note-taking for lectures and while watching the accompanying videos.
3. **Schedule time to do some math every day.** Exercise, foreign language study, and math are three things that you must do every day to get the results you want. If you are used to cramming and doing all of your work in a few hours on a weekend, you should know that even mathematicians start making silly errors after an hour or so! Check your answers. Skill Practice exercises all have the answers at the bottom of that page. Odd-numbered exercises throughout the text have answers in the back of the text. If you didn't get it right, don't throw in the towel. Try again, revisit an example, or bring your questions to class for extra help.
4. **Prepare for quizzes and exams.** Each chapter has a set of Chapter Review Exercises at the end to help you integrate all of the important concepts. In addition, there is a detailed Chapter Summary and a Chapter Test. If you use ALEKS or Connect Hosted by ALEKS, use all of the tools available within the program to test your understanding.
5. **Use your resources.** This text comes with numerous supporting resources designed to help you succeed in this class and your future classes. Additionally, your instructor can direct you to resources within your institution or community. Form a student study group. Teaching others is a great way to strengthen your own understanding, and they might be able to return the favor if you get stuck.

We wish you all the best in this class and your educational journey!

Julie Miller
julie.miller.math@gmail.com

Molly O'Neill
molly.s.oneill@gmail.com

Nancy Hyde
nhyde@montanasky.com

Student Guide to the Text

Clear, Precise Writing

Learning from our own students, we have written this text in simple and accessible language. Our goal is to keep you engaged and supported throughout your coursework.

Call-Outs

Just as your instructor will share tips and math advice in class, we provide call-outs throughout the text to offer tips and warn against common mistakes.

- Tip boxes offer additional insight to a concept or procedure.
- Avoiding Mistakes help fend off common student errors.

Examples

- Each example is step-by-step, with thorough annotation to the right explaining each step.
- Following each example is a similar **Skill Practice** exercise to give you a chance to test your understanding. You will find the answer at the bottom of the page—providing a quick check.
- When you see this 

in an example, there is an online dynamic animation within your online materials. Sometimes an animation is worth a thousand words.

Exercise Sets

Each type of exercise is built so you can successfully learn the materials and show your mastery on exams.

- **Study Skills Exercises** integrate your studies of math concepts with strategies for helping you grow as a student overall.
- **Vocabulary and Key Concept Exercises** check your understanding of the language and ideas presented within the section.
- **Review Exercises** keep fresh your knowledge of math content already learned by providing practice with concepts explored in previous sections.
- **Concept Exercises** assess your comprehension of the specific math concepts presented within the section.
- **Mixed Exercises** evaluate your ability to successfully complete exercises that combine multiple concepts presented within the section.
- **Expanding Your Skills** challenge you with advanced skills practice exercises around the concepts presented within the section.
- **Problem Recognition Exercises** appear in strategic locations in each chapter of the text. These will require you to distinguish between similar problem types and to determine what type of problem-solving technique to apply.

Calculator Connections

Throughout the text are materials highlighting how you can use a graphing calculator to enhance understanding through a visual approach. Your instructor will let you know if you will be using these in class.

End-of-Chapter Materials

The features at the end of each chapter are perfect for reviewing before test time.

- **Section-by-section summaries** provide references to key concepts, examples, and vocabulary.
- **Chapter Review Exercises** provide additional opportunities to practice material from the entire chapter.
- **Chapter tests** are an excellent way to test your complete understanding of the chapter concepts.
- **Group Activities** promote classroom discussion and collaboration. These activities help you solve problems and explain their solutions for better mathematical mastery. Group Activities are great for bringing a more interactive approach to your learning.

Get Better Results

How Will Miller/O'Neill/Hyde Help Your Students *Get Better Results?*

Clarity, Quality, and Accuracy

Julie Miller, Molly O'Neill, and Nancy Hyde know what students need to be successful in mathematics. Better results come from clarity in their exposition, quality of step-by-step worked examples, and accuracy of their exercises sets; but it takes more than just great authors to build a textbook series to help students achieve success in mathematics. Our authors worked with a strong team of mathematics instructors from around the country to ensure that the clarity, quality, and accuracy you expect from the Miller/O'Neill/Hyde series was included in this edition.

Exercise Sets

Comprehensive sets of exercises are available for every student level. Julie Miller, Molly O'Neill, and Nancy Hyde worked with a board of advisors from across the country to offer the appropriate depth and breadth of exercises for your students. **Problem Recognition Exercises** were created to improve student performance while testing.

Practice exercise sets help students progress from skill development to conceptual understanding. Student tested and instructor approved, the Miller/O'Neill/Hyde exercise sets will help your students *get better results*.

- **Problem Recognition Exercises**
- **Skill Practice Exercises**
- **Study Skills Exercises**
- **Mixed Exercises**
- **Expanding Your Skills Exercises**
- **Vocabulary and Key Concepts Exercises**

Step-By-Step Pedagogy

Prealgebra & Introductory Algebra provides enhanced step-by-step learning tools to help students *get better results.*

- **Worked Examples** provide an "easy-to-understand" approach, clearly guiding each student through a step-by-step approach to master each practice exercise for better comprehension.
- **TIPs** offer students extra cautious direction to help improve understanding through hints and further insight.
- **Avoiding Mistakes** boxes alert students to common errors and provide practical ways to avoid them. Both of these learning aids will help students get better results by showing how to work through a problem using a clearly defined step-by-step methodology that has been class tested and student approved.

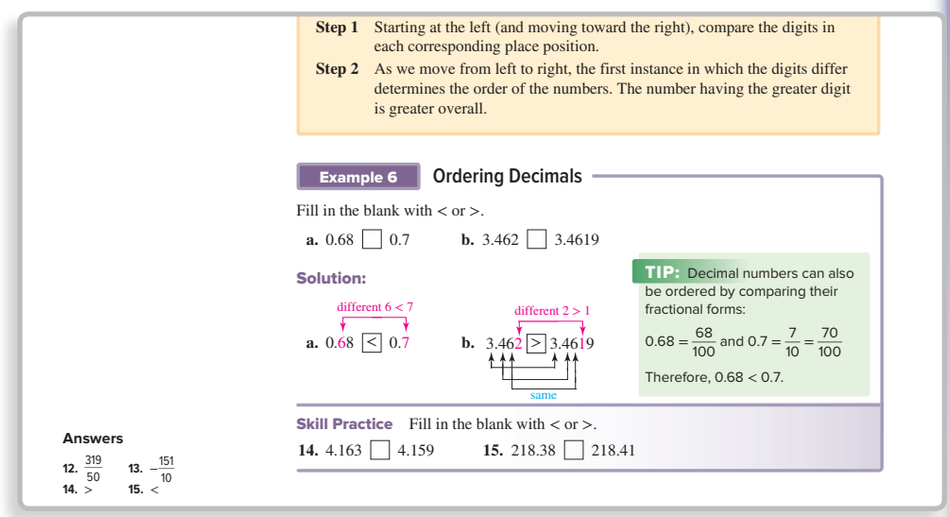
Get Better Results

Formula for Student Success

Step-by-Step Worked Examples

- Do you get the feeling that there is a disconnect between your students' class work and homework?
- Do your students have trouble finding worked examples that match the practice exercises?
- Do you prefer that your students see examples in the textbook that match the ones you use in class?

Miller/O'Neill/Hyde's *Worked Examples* offer a clear, concise methodology that replicates the mathematical processes used in the authors' classroom lectures.



Step 1 Starting at the left (and moving toward the right), compare the digits in each corresponding place position.

Step 2 As we move from left to right, the first instance in which the digits differ determines the order of the numbers. The number having the greater digit is greater overall.

Example 6 Ordering Decimals

Fill in the blank with $<$ or $>$.

a. $0.68 \square 0.7$ **b.** $3.462 \square 3.4619$

Solution:

a. $0.68 \;\boxed{<}\; 0.7$ (different 6 < 7)

b. $3.462 \;\boxed{>}\; 3.4619$ (different 2 > 1; same)

TIP: Decimal numbers can also be ordered by comparing their fractional forms:

$0.68 = \frac{68}{100}$ and $0.7 = \frac{7}{10} = \frac{70}{100}$

Therefore, $0.68 < 0.7$.

Skill Practice Fill in the blank with $<$ or $>$.

14. $4.163 \square 4.159$ **15.** $218.38 \square 218.41$

Answers

12. $\frac{319}{50}$ **13.** $-\frac{151}{10}$
14. $>$ **15.** $<$

Classroom Examples

To ensure that the classroom experience also matches the examples in the text and the practice exercises, we have included references to even-numbered exercises to be used as Classroom Examples. These exercises are highlighted in the Practice Exercises at the end of each section.

51. The perimeter of a triangle is 21.5 yd. The longest side is twice the shortest side. The middle side is 3.1 yd longer than the shortest side. Find the lengths of the sides. **(See Example 7.)**

52. The perimeter of a triangle is 2.5 m. The longest side is 2.4 times the shortest side, and the middle side is 0.3 m more than the shortest side. Find the lengths of the sides.

53. Toni, Rafa, and Henri are all servers at the Chez Joëlle Restaurant. The tips collected for the night amount to $167.80. Toni made $22.05 less in tips than Rafa. Henri made $5.90 less than Rafa. How much did each person make?

54. Bob bought a popcorn, a soda, and a hotdog at the movies for $8.25. Popcorn costs $1 more than a hotdog. A soda costs $0.25 less than a hotdog. How much is each item?

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Get Better Results

Quality Learning Tools

TIP and Avoiding Mistakes Boxes

TIP and **Avoiding Mistakes** boxes have been created based on the authors' classroom experiences—they have also been integrated into the **Worked Examples.** These pedagogical tools will help students get better results by learning how to work through a problem using a clearly defined step-by-step methodology.

$= \frac{1.25}{2}$ qt — Multiply fractions.

$= 0.625$ qt — Simplify.

b. $2 \text{ gal} = 2 \text{ gal} \cdot \frac{4 \text{ qt}}{1 \text{ gal}} \cdot \frac{4 \text{ c}}{1 \text{ qt}}$ — Use two conversion factors. The first converts gallons to quarts. The second converts quarts to cups.

$= \frac{2 \text{ gal}}{1} \cdot \frac{4 \text{ qt}}{1 \text{ gal}} \cdot \frac{4 \text{ c}}{1 \text{ qt}}$

$= 32$ c — Multiply.

c. $48 \text{ fl oz} = \frac{48 \text{ fl oz}}{1} \cdot \frac{1 \text{ c}}{8 \text{ fl oz}} \cdot \frac{1 \text{ qt}}{4 \text{ c}} \cdot \frac{1 \text{ gal}}{4 \text{ qt}}$ — Convert from fluid ounces to cups, from cups to quarts, and from quarts to gallons.

$= \frac{48}{128}$ gal

$= \frac{3}{8}$ gal or 0.375 gal

Skill Practice Convert.

14. 8.5 gal = _____ qt **15.** 2.25 qt = _____ c **16.** 40 fl oz = _____ qt

Animation

Avoiding Mistakes

It is important to note that ounces (oz) and fluid ounces (fl oz) are different quantities. An ounce (oz) is a measure of weight, and a fluid ounce (fl oz) is a measure of capacity. Furthermore,

16 oz = 1 lb
8 fl oz = 1 c

Answers

13. 12 lb 1 oz **14.** 34 qt
15. 9 c **16.** 1.25 qt

Avoiding Mistakes Boxes:

Avoiding Mistakes boxes are integrated throughout the textbook to alert students to common errors and how to avoid them.

TIP: To use the prefix line effectively, you must know the order of the metric prefixes. Sometimes a mnemonic (memory device) can help. Consider the following sentence. The first letter of each word represents one of the metric prefixes.

kids	have	doughnuts	until	dad	calls	mom.
kilo-	hecto-	deka-	unit	deci-	centi-	milli-

represents the main unit of measurement (meter, liter, or gram)

TIP Boxes

Teaching tips are usually revealed only in the classroom. Not anymore! TIP boxes offer students helpful hints and extra direction to help improve understanding and provide further insight.

Get Better Results

Better Exercise Sets and Better Practice Yields Better Results

- Do your students have trouble with problem solving?
- Do you want to help students overcome math anxiety?
- Do you want to help your students improve performance on math assessments?

Problem Recognition Exercises

Problem Recognition Exercises present a collection of problems that look similar to a student upon first glance, but are actually quite different in the manner of their individual solutions. Students sharpen critical thinking skills and better develop their "solution recall" to help them distinguish the method needed to solve an exercise—an essential skill in mathematics.

Problem Recognition Exercises were tested in the authors' developmental mathematics classes and were created to improve student performance on tests.

Problem Recognition Exercises

Operations on Whole Numbers

For Exercises 1–14, perform the indicated operations.

1. a. $\begin{array}{r} 96 \\ +\ 24 \\ \hline \end{array}$	**b.** $\begin{array}{r} 96 \\ -\ 24 \\ \hline \end{array}$	**c.** $\begin{array}{r} 96 \\ \times\ 24 \\ \hline \end{array}$	**d.** $24\overline{)96}$
2. a. $\begin{array}{r} 550 \\ +\ 25 \\ \hline \end{array}$	**b.** $\begin{array}{r} 550 \\ -\ 25 \\ \hline \end{array}$	**c.** $\begin{array}{r} 550 \\ \times\ 25 \\ \hline \end{array}$	**d.** $25\overline{)550}$
3. a. $\begin{array}{r} 612 \\ +\ 334 \\ \hline \end{array}$	**b.** $\begin{array}{r} 946 \\ -\ 334 \\ \hline \end{array}$	**4. a.** $\begin{array}{r} 612 \\ -\ 334 \\ \hline \end{array}$	**b.** $\begin{array}{r} 278 \\ +\ 334 \\ \hline \end{array}$
5. a. $\begin{array}{r} 5500 \\ -\ 4299 \\ \hline \end{array}$	**b.** $\begin{array}{r} 1201 \\ +\ 4299 \\ \hline \end{array}$	**6. a.** $\begin{array}{r} 22{,}718 \\ +\ 12{,}137 \\ \hline \end{array}$	**b.** $\begin{array}{r} 34{,}855 \\ -\ 12{,}137 \\ \hline \end{array}$
7. a. $50 \cdot 400$	**b.** $20{,}000 \div 50$	**8. a.** $548 \cdot 63$	**b.** $34{,}524 \div 63$
9. a. $5060 \div 22$	**b.** $230 \cdot 22$	**10. a.** $1875 \div 125$	**b.** $125 \cdot 15$
11. a. $4\overline{)1312}$	**b.** $328\overline{)1312}$	**12. a.** $547\overline{)4376}$	**b.** $8\overline{)4376}$
13. a. $418 \cdot 10$	**b.** $418 \cdot 100$	**c.** $418 \cdot 1000$	**d.** $418 \cdot 10{,}000$
14. a. $350{,}000 \div 10$	**b.** $350{,}000 \div 100$	**c.** $350{,}000 \div 1000$	**d.** $350{,}000 \div 10{,}000$

Get Better Results

Student Centered Applications

The Miller/O'Neill/Hyde Board of Advisors partnered with our authors to bring the *best applications* from every region in the country! These applications include real data and topics that are more relevant and interesting to today's student.

63. Fifty-two percent of American parents have started to put money away for their children's college education. In a survey of 800 parents, how many would be expected to have started saving for their children's education? (*Source: USA TODAY*) **(See Example 9.)**

64. Forty-four percent of Americans used online travel sites to book hotel or airline reservations. If 400 people need to make airline or hotel reservations, how many would be expected to use online travel sites?

65. Brian has been saving money to buy a 55-in. television. He has saved $1440 so far, but this is only 60% of the total cost of the television. What is the total cost?

66. Recently the number of females that were home-schooled for grades K–12 was 875 thousand. This is 202% of the number of females home-schooled in 1999. How many females were home-schooled in 1999? Round to the nearest thousand. (*Source:* National Center for Educational Statistics)

67. Mr. Asher made $49,000 as a teacher in Virginia in 2010, and he spent $8,800 on food that year. In 2011, he received a 4% increase in his salary, but his food costs increased by 6.2%.

a. How much money was left from Mr. Asher's 2010 salary after subtracting the cost of food?

b. How much money was left from his 2011 salary after subtracting the cost of food? Round to the nearest dollar.

68. The human body is 65% water. Mrs. Wright weighed 180 lb. After 1 year on a diet, her weight decreased by 15%.

a. Before the diet, how much of Mrs. Wright's weight was water?

b. After the diet, how much of Mrs. Wright's weight was water?

Group Activities

Each chapter concludes with a Group Activity to promote classroom discussion and collaboration—helping students not only to solve problems but to explain their solutions for better mathematical mastery. Group Activities are great for both full-time and adjunct instructors—bringing a more interactive approach to teaching mathematics! All required materials, activity time, and suggested group sizes are provided in the end-of-chapter material.

Chapter 3 Group Activity

Deciphering a Coded Message

Materials: Pencil and paper

Estimated Time: 20 minutes

Group Size: Pairs

Cryptography is the study of coding and decoding messages. One type of coding process assigns a number to each letter of the alphabet and to the space character. For example:

A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	2	3	4	5	6	7	8	9	10	11	12	13	14

O	P	Q	R	S	T	U	V	W	X	Y	Z	space
15	16	17	18	19	20	21	22	23	24	25	26	27

According to the number assigned to each letter, the message "Do the Math" would be coded as follows:

D O _ T H E _ M A T H
4 / 15 / 27 / 20 / 8 / 5 / 27 / 13 / 1 / 20 / 8

Now suppose each letter is encoded by applying a formula such as $x + 3 = y$, where x is the original number of the letter and y is the code number of the letter. For example, the letter A would be coded by $1 + 3 = 4$, B would be coded $2 + 3 = 5$, and so on.

Using this encoding, we have

Message: D O _ T H E _ M A T H

Original: 4 / 15 / 27 / 20 / 8 / 5 / 27 / 13 / 1 / 20 / 8

Coded form: 7 / 18 / 30 / 23 / 11 / 8 / 30 / 16 / 4 / 23 / 11

To decode this message, the receiver would need to reverse the operation by solving for x, that is, use the formula $x = y - 3$.

1. Each pair of students will encode the message by adding 3 to each number:

Life is too short for long division.

2. Each pair of students will decode the message by subtracting 3 from each number.

17 / 4 / 23 / 24 / 21 / 4 / 15 / 30 / 17 / 24 / 16 / 5 / 8 / 21 / 22 / 30 / 4 / 21 / 8 / 30 /
10 / 18 / 18 / 7 / 30 / 9 / 18 / 21 / 30 / 28 / 18 / 24 / 21 / 30 / 11 / 8 / 4 / 15 / 23 / 11

Get Better Results

Additional Supplements

Lecture Videos Created by the Authors

Julie Miller began creating these lecture videos for her own students to use when they were absent from class. The student response was overwhelmingly positive, prompting the author team to create the lecture videos for their entire developmental math book series. In these videos, the authors walk students through the learning objectives using the same language and procedures outlined in the book. Students learn and review right alongside the author! Students can also access the written notes that accompany the videos.

NEW Integrated Video and Study Workbooks

The Integrated Video and Study Workbooks were built to be used in conjunction with the Miller/O'Neill/Hyde Developmental Math series online lecture videos. These new video guides allow students to consolidate their notes as they work through the material in the book, and they provide students with an opportunity to focus their studies on particular topics that they are struggling with rather than entire chapters at a time. Each video guide contains written examples to reinforce the content students are watching in the corresponding lecture video, along with additional written exercises for extra practice. There is also space provided for students to take their own notes alongside the guided notes already provided. By the end of the academic term, the video guides will not only be a robust study resource for exams, but will serve as a portfolio showcasing the hard work of students throughout the term.

Dynamic Math Animations

The authors have constructed a series of animations to illustrate difficult concepts where static images and text fall short. The animations leverage the use of on-screen movement and morphing shapes to give students an interactive approach to conceptual learning. Some provide a virtual laboratory for which an application is simulated and where students can collect data points for analysis and modeling. Others provide interactive question-and-answer sessions to test conceptual learning.

Exercise Videos

The authors, along with a team of faculty who have used the Miller/O'Neill/Hyde textbooks for many years, have created exercise videos for designated exercises in the textbook. These videos cover a representative sample of the main objectives in each section of the text. Each presenter works through selected problems, following the solution methodology employed in the text.

The video series is available online as part of Connect Math hosted by ALEKS as well as in ALEKS 360. The videos are closed-captioned for the hearing impaired and meet the Americans with Disabilities Act Standards for Accessible Design.

SmartBook

SmartBook is the first and only adaptive reading experience available for the world of higher education, and it facilitates the reading process by identifying what content a student knows and doesn't know. As a student reads, the material continuously adapts to ensure the student is focused on the content he or she needs the most to close specific knowledge gaps.

Student Resource Manual

The *Student Resource Manual (SRM),* created by the authors, is a printable, electronic supplement available to students through Connect Math hosted by ALEKS. Instructors can also choose to customize this manual and package with their course materials. With increasing demands on faculty schedules, this resource offers a convenient means for both full-time and adjunct faculty to promote active learning and success strategies in the classroom.

This manual supports the series in a variety of different ways:

- Additional Group Activities developed by the authors to supplement what is already available in the text
- Discovery-based classroom activities written by the authors for each section

Get Better Results

- Excel activities that not only provide students with numerical insights into algebraic concepts, but also teach simple computer skills to manipulate data in a spreadsheet
- Worksheets for extra practice written by the authors, including Problem Recognition Exercise Worksheets
- Lecture Notes designed to help students organize and take notes on key concepts
- Materials for a student portfolio

Annotated Instructor's Edition

In the *Annotated Instructor's Edition* (*AIE*), answers to all exercises appear adjacent to each exercise in a color used *only* for annotations. The *AIE* also contains Instructor Notes that appear in the margin. These notes offer instructors assistance with lecture preparation. In addition, there are Classroom Examples referenced in the text that are highlighted in the Practice Exercises. Also found in the *AIE* are icons within the Practice Exercises that serve to guide instructors in their preparation of homework assignments and lessons.

PowerPoints

The PowerPoints present key concepts and definitions with fully editable slides that follow the textbook. An instructor may project the slides in class or post to a website in an online course.

Test Bank

Among the supplements is a computerized test bank using the algorithm-based testing software TestGen® to create customized exams quickly. Hundreds of text-specific, open-ended, and multiple-choice questions are included in the question bank.

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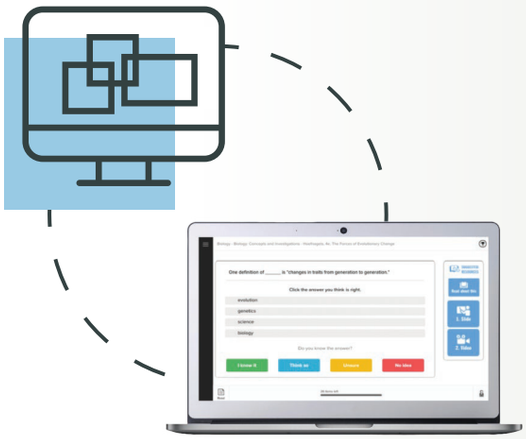

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ALEKS® Creates a Personalized and Dynamic Learning Path

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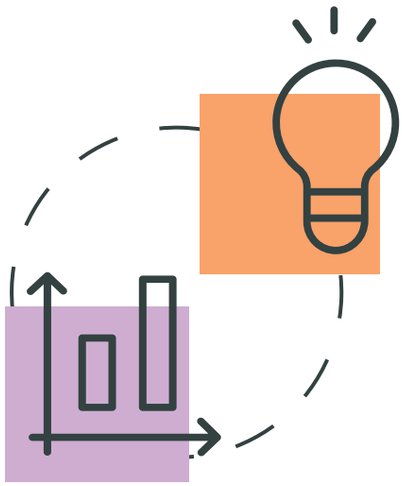
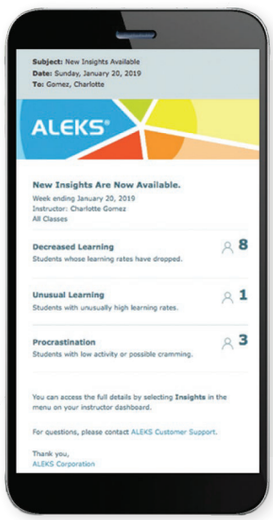
*visit **bit.ly/outcomesandefficacy** to review empirical data from ALEKS® users around the country





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ALEKS® Reports are designed to inform your instruction and create more meaningful interactions with your students when they need it the most. ALEKS® Insights alert you when students might be at risk of falling behind so that you can take immediate action. Insights summarize students exhibiting at least one of four negative behaviors that may require intervention including Failed Topics, Decreased Learning, Unusual Learning and Procrastination & Cramming.

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1 Whole Numbers

CHAPTER OUTLINE

Numbers on Vacation

Since the beginning of human civilization, the need to communicate with one another in a precise, quantifiable language has become increasingly important. For example, to take a vacation to Disney World, a family would want to know the driving distance to the park, the time required to drive there, the cost for tickets, the number of nights for a hotel room, and the estimated amount spent on food and incidentals. Such numerical (quantifiable) information is essential for the family to determine if the vacation is affordable and to form a budget for the vacation.

Suppose the family lives 300 miles from Disney World, drives a car that gets 30 miles per gallon of gasoline, and travels 60 miles per hour. These numerical values are called whole numbers. Whole numbers include 0 and the counting numbers 1, 2, 3, and so on. Operations on whole numbers can help us solve a variety of applications. For example, dividing the whole number 300 miles by 30 miles per gallon tells us that the family will use 10 gallons of gasoline. Furthermore, dividing 300 miles by 60 miles per hour tells us that the family will arrive at Disney World in 5 hours. As you work through this chapter, reflect on how important numbers are to everyday living and how different our world would be without the precision of numerical values.

Section 1.1 Study Tips

Concepts

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In taking a course in algebra, you are making a commitment to yourself, your instructor, and your classmates. Following some or all of the study tips presented here can help you to be successful in this endeavor. The features of this text that will assist you are printed in blue.

1. Before the Course

1. Purchase the necessary materials for the course before the course begins or on the first day.
2. Obtain a three-ring binder to keep and organize your notes, homework, tests, and any other materials acquired in the class. We call this type of notebook a portfolio.
3. Arrange your schedule so that you have enough time to attend class and to do homework. A common rule is to set aside at least 2 hours for homework for every hour spent in class. That is, if you are taking a 4-credit-hour course, plan on at least 8 hours a week for homework. A 6-credit-hour course will then take *at least* 12 hours each week—about the same as a part-time job. If you experience difficulty in mathematics, plan for more time.
4. Communicate with your employer and family members the importance of your success in this course so that they can support you.
5. Be sure to find out the type of calculator (if any) that your instructor requires.

2. During the Course

1. Read the section in the text *before* the lecture to familiarize yourself with the material and terminology. It is recommended that you read your math book with paper and pencil in hand. Write a one-sentence preview of what the section is about.
2. Attend every class, and be on time. Be sure to bring any materials that are needed for class such as graph paper, a ruler, or a calculator.
3. Take notes in class. Write down all of the examples that the instructor presents. Read the notes after class, and add any comments to make your notes clearer to you. Use a tape recorder to record the lecture if the instructor permits the recording of lectures.
4. Ask questions in class.
5. Read the section in the text *after* the lecture, and pay special attention to the Tip boxes and Avoiding Mistakes boxes.
6. After you read an example, try the accompanying Skill Practice problem. The skill practice problem mirrors the example and tests your understanding of what you have read.
7. Do homework every day. Even if your class does not meet every day, you should still do some work every day to keep the material fresh in your mind.
8. Check your homework with the answers that are supplied in the back of this text. Correct the exercises that do not match, and circle or star those that you cannot correct yourself. This way you can easily find them and ask your instructor, tutor, online tutor, or math lab staff the next day.
9. Be sure to do the Vocabulary and Key Concepts exercises found at the beginning of the Practice Exercises.
10. The Problem Recognition Exercises are located in all chapters. These provide additional practice distinguishing among a variety of problem types. Sometimes the most difficult part of learning mathematics is retaining all that you learn. These exercises are excellent tools for retention of material.
11. Form a study group with fellow students in your class, and exchange phone numbers. You will be surprised by how much you can learn by talking about mathematics with other students.
12. If you use a calculator in your class, read the Calculator Connections boxes to learn how and when to use your calculator.
13. Ask your instructor where you might obtain extra help if necessary.

3. Preparation for Exams

1. Look over your homework. Pay special attention to the exercises you have circled or starred to be sure that you have learned that concept.
2. Begin preparations for exams on the first day of class. As you do each homework assignment, think about how you would recognize similar problems when they appear on a test.
3. Work through the Chapter Review exercises found at the end of each chapter.
4. For additional help, use the online resources such as the Chapter Summary and Chapter Test.

4. Where to Go for Help

1. At the first sign of trouble, see your instructor. Most instructors have specific office hours set aside to help students. Don't wait until after you have failed an exam to seek assistance.
2. Get a tutor. Most colleges and universities have free tutoring available. There may also be an online tutor available.
3. When your instructor and tutor are unavailable, use the Student Solutions Manual for step-by-step solutions to the odd-numbered problems in the exercise sets.
4. Work with another student from your class.
5. Work on the computer. Many mathematics tutorial programs and websites are available on the Internet, including the website that accompanies this text.

Chapter 1 Group Activity

Becoming a Successful Student

Materials: Computer with Internet access (Optional)

Estimated Time: 15 minutes

Group Size: 4

Good time management, good study skills, and good organization will help you to be successful in this course. Answer the following questions and compare your answers with your group members.

1. To motivate yourself to complete a course, it is helpful to have clear reasons for taking the course. List your goals for taking this course and discuss them with your group.

2. For the next week, write down the times each day that you plan to study math.

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday

3. Write down the date of your next math test. _____

4. Taking 12 credit-hours is the equivalent of a full-time job. Often students try to work too many hours while taking classes at school.

a. Write down the number of hours you work per week and the number of credit-hours you are taking this term.

Number of hours worked per week _____

Number of credit-hours this term _____

b. The table gives a recommended limit to the number of hours you should work for the number of credit-hours you are taking at school. (Keep in mind that other responsibilities in your life such as your family might also make it necessary to limit your hours at work even more.) How do your numbers from part (a) compare to those in the table? Are you working too many hours?

Number of Credit-Hours	Maximum Number of Hours of Work per Week
3	40
6	30
9	20
12	10
15	0

5. Discuss with your group members where you can go for extra help in math. Then write down three of the suggestions.

_____

_____

_____

6. Do you keep an organized notebook for this class? Can you think of any suggestions that you can share with your group members to help them keep their materials organized?

7. Look through one of the chapters in your text and find the page numbers corresponding to the Problem Recognition exercises and Chapter Review exercises. Discuss with your group members how you might use each feature.

Problem Recognition Exercises: page _____

Chapter Review Exercises: page _____

8. Look at the Skill Practice exercises that follow the examples. Where are the answers to these exercises located? Discuss with your group members how you might use the Skill Practice exercises.

9. Do you think that you have math anxiety? Read the following list for some possible solutions. Check the activities that you can realistically try to help you overcome this problem.

_____ Read a book on math anxiety.

_____ Search the Web for tips on handling math anxiety.

_____ See a counselor to discuss your anxiety.

_____ Talk with your instructor to discuss strategies to manage math anxiety.

_____ Evaluate your time management to see if you are trying to do too much. Then adjust your schedule accordingly.

10. Some students favor different methods of learning over others. For example, you might prefer:

- Learning through listening and hearing.
- Learning through seeing images, watching demonstrations, and visualizing diagrams and charts.
- Learning by experience through a hands-on approach.
- Learning through reading and writing.

Most experts believe that the most effective learning comes when a student engages in *all* of these activities. However, each individual is different and may benefit from one activity more than another. You can visit a number of different websites to determine your "learning style." Try doing a search on the Internet with the key words "*learning styles assessment.*" Once you have found a suitable website, answer the questionnaire and the site will give you feedback on what method of learning works best for you.

Introduction to Whole Numbers

Section 1.2

1. Place Value

Concepts

Numbers provide the foundation that is used in mathematics. We begin this chapter by discussing how numbers are represented and named. All numbers in our numbering system are composed from the **digits** 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9. In mathematics, the numbers 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, . . . are called the *whole numbers.* (The three dots are called *ellipses* and indicate that the list goes on indefinitely.)

For large numbers, commas are used to separate digits into groups of three called **periods**. For example, the number of live births in the United States in a recent year was 4,058,614. (*Source: The World Almanac*) Numbers written in this way are said to be in **standard form**. The position of each digit determines the place value of the digit. To interpret the number of births in the United States, refer to the place value chart (Figure 1-1).

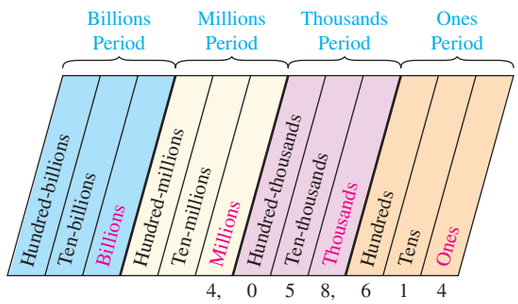

Figure 1-1

The digit 5 in 4,058,614 represents 5 ten-thousands because it is in the ten-thousands place. The digit 4 on the left represents 4 millions, whereas the digit 4 on the right represents 4 ones.

Example 1 **Determining Place Value**

Determine the place value of the digit 2.

a. 417,216,900 **b.** 724 **c.** 502,000,700

Solution:

a. 417,216,900 hundred-thousands

b. 724 tens

c. 502,000,700 millions

Skill Practice Determine the place value of the digit 4.

1. 547,098,632
2. 1,659,984,036
3. 6420

Answers

1. Ten-millions
2. Thousands
3. Hundreds

Example 2 **Determining Place Value**

The altitude of Mount Everest, the highest mountain on Earth, is 29,035 feet (ft). Give the place value for each digit.

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Solution:

29,035
- ones
- tens
- hundreds
- thousands
- ten-thousands

Skill Practice

4. Alaska is the largest state geographically. Its land area is 571,962 square miles (mi^2). Give the place value for each digit.

2. Standard Notation and Expanded Notation

A number can also be written in an expanded form by writing each digit with its place value unit. For example, 287 can be written as

$$\begin{aligned} 287 &= 2 \text{ hundreds} + 8 \text{ tens} + 7 \text{ ones} \\ &= 2 \times 100 + 8 \times 10 + 7 \times 1 \\ &= 200 + 80 + 7 \end{aligned}$$

This is called **expanded form**.

Example 3 **Converting Standard Form to Expanded Form**

Convert to expanded form.

a. 4,672 **b.** 257,016

Solution:

a. 4,672

$$\begin{aligned} &4 \text{ thousands} + 6 \text{ hundreds} + 7 \text{ tens} + 2 \text{ ones} \\ &= 4 \times 1{,}000 + 6 \times 100 + 7 \times 10 + 2 \times 1 \\ &= 4{,}000 + 600 + 70 + 2 \end{aligned}$$

b. 257,016

$$\begin{aligned} &2 \text{ hundred-thousands} + 5 \text{ ten-thousands} + \\ &7 \text{ thousands} + 1 \text{ ten} + 6 \text{ ones} \\ &= 2 \times 100{,}000 + 5 \times 10{,}000 + 7 \times 1{,}000 + 1 \times 10 + 6 \times 1 \\ &= 200{,}000 + 50{,}000 + 7{,}000 + 10 + 6 \end{aligned}$$

Skill Practice Convert to expanded form.

5. 837 **6.** 4,093,062

Answers

4. 5: hundred-thousands
7: ten-thousands
1: thousands 9: hundreds
6: tens 2: ones

5. 8 hundreds + 3 tens + 7 ones;
$8 \times 100 + 3 \times 10 + 7 \times 1$

6. 4 millions + 9 ten-thousands + 3 thousands + 6 tens + 2 ones;
$4 \times 1{,}000{,}000 + 9 \times 10{,}000 + 3 \times 1{,}000 + 6 \times 10 + 2 \times 1$

Example 4 **Converting Expanded Form to Standard Form**

Convert to standard form.

a. 2 hundreds + 5 tens + 9 ones

b. 1 thousand + 2 tens + 5 ones

Solution:

a. 2 hundreds + 5 tens + 9 ones = 259

b. Each place position from the thousands place to the ones place must contain a digit. In this problem, there is no reference to the hundreds place digit. Therefore, we assume 0 hundreds. Thus,

1 thousand + 0 hundreds + 2 tens + 5 ones = 1,025

Skill Practice Convert to standard form.

7. 8 thousands + 5 hundreds + 5 tens + 1 one

8. 5 hundred-thousands + 4 thousands + 8 tens + 3 ones

3. Writing Numbers in Words

The word names of some two-digit numbers appear with a hyphen, while others do not. For example:

Number	Number Name
12	twelve
68	sixty-eight
40	forty
42	forty-two

To write a three-digit or larger number, begin at the leftmost group of digits. The number named in that group is followed by the period name, followed by a comma. Then the next period is named, and so on.

Example 5 **Writing a Number in Words**

Write 621,417,325 in words.

Solution:

621,417,325

six hundred twenty-one million,

four hundred seventeen thousand,

three hundred twenty-five

Skill Practice

9. Write 1,450,327,214 in words.

Notice from Example 5 that when naming numbers, the name of the ones period is not attached to the last group of digits. Also note that for whole numbers, the word *and* should not appear in word names. For example, 405 should be written as four hundred five.

Answers

7. 8,551 **8.** 504,083

9. One billion, four hundred fifty million, three hundred twenty-seven thousand, two hundred fourteen

Example 6 **Writing a Number in Standard Form**

Write the number in standard form.

Six million, forty-six thousand, nine hundred three

Solution:

six million nine hundred three

6,046,903

forty-six thousand

Skill Practice

10. Write the number in standard form: fourteen thousand, six hundred nine.

We have seen several examples of writing a number in standard form, in expanded form, and in words. Standard form is the most concise representation. Also note that when we write a four-digit number in standard form, the comma is often omitted. For example, 4,389 is often written as 4389.

4. The Number Line and Order

Whole numbers can be visualized as equally spaced points on a line called a *number line* (Figure 1-2).

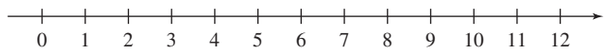
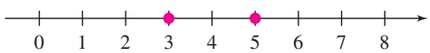


Figure 1-2

The whole numbers begin at 0 and are ordered from left to right by increasing value.

A number is graphed on a number line by placing a dot at the corresponding point. For any two numbers graphed on a number line, the number to the left is less than the number to the right. Similarly, a number to the right is greater than the number to the left. In mathematics, the symbol $<$ is used to denote "is less than," and the symbol $>$ means "is greater than." Therefore,

$3 < 5$ means 3 is less than 5
$5 > 3$ means 5 is greater than 3



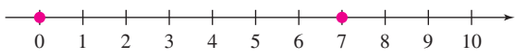
Example 7 **Determining Order of Two Numbers**

Fill in the blank with the symbol $<$ or $>$.

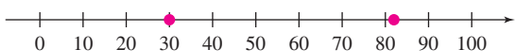
a. $7 \square 0$ **b.** $30 \square 82$

Solution:

a. $7 \boxed{>} 0$



b. $30 \boxed{<} 82$



To visualize 82 and 30 on the number line, it may be necessary to use a different scale. Rather than setting equally spaced marks in units of 1, we can use units of 10. Then 82 must be somewhere between 80 and 90 on the number line.

Skill Practice Fill in the blank with the symbol $<$ or $>$.

11. $9 \square 5$ **12.** $8 \square 18$

Answers
10. 14,609
11. $>$ **12.** $<$

Section 1.2 Practice Exercises

Study Skills Exercise

In this text, we provide skills for you to enhance your learning experience. Many of the practice exercises begin with an activity that focuses on one of seven areas: learning about your course, using your text, taking notes, doing homework, taking an exam (test and math anxiety), managing your time, and studying for the final exam.

Each activity requires only a few minutes and will help you pass this class and become a better math student. Many of these skills can be carried over to other disciplines and help you become a model college student.

To begin, write down the following information.

a. Instructor's name

b. Instructor's office number

c. Instructor's telephone number

d. Instructor's email address

e. Instructor's office hours

f. Days of the week that the class meets

g. The room number in which the class meets

h. Is there a lab requirement for this course? If so, where is the lab located and how often must you go?

Vocabulary and Key Concepts

1. a. For large numbers, commas are used to separate digits into groups called _____.

b. The place values of the digits in the ones period are the ones, tens, and _____ places.

c. The place values of the digits in the _____ period are the thousands, ten-thousands, and hundred-thousands places.

Concept 1: Place Value

2. Name the place value for each digit in 36,791.

3. Name the place value for each digit in 8,213,457.

4. Name the place value for each digit in 103,596.

For Exercises 5–24, determine the place value for each underlined digit. **(See Example 1.)**

5. 3$\underline{2}$1

6. 6$\underline{8}$9

7. 21$\underline{4}$

8. 73$\underline{8}$

9. 8,$\underline{7}$10

10. 2,$\underline{2}$93

11. $\underline{1}$,430

12. $\underline{3}$,101

13. $\underline{4}$52,723

14. $\underline{6}$55,878

15. $\underline{1}$,023,676,207

16. $\underline{3}$,111,901,211

17. $\underline{2}$2,422

18. $\underline{5}$8,106

19. 5$\underline{1}$,033,201

20. 9$\underline{3}$,971,224

21. The number of U.S. travelers abroad in a recent year was $\underline{1}$0,677,881. **(See Example 2.)**

22. The area of Lake Superior is 3$\underline{1}$,820 square miles (mi^2).

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23. For a recent year, the total number of U.S. $1 bills in circulation was 7,653,468,440.

24. For a certain flight, the cruising altitude of a commercial jet is 31,000 ft.

Concept 2: Standard Notation and Expanded Notation

For Exercises 25–32, convert the numbers to expanded form. **(See Example 3.)**

25. 58 **26.** 71 **27.** 539 **28.** 382

29. 5,203 **30.** 7,089 **31.** 10,241 **32.** 20,873

For Exercises 33–40, convert the numbers to standard form. **(See Example 4.)**

33. 5 hundreds + 2 tens + 4 ones

34. 3 hundreds + 1 ten + 8 ones

35. 1 hundred + 5 tens

36. 6 hundreds + 2 tens

37. 1 thousand + 9 hundreds + 6 ones

38. 4 thousands + 2 hundreds + 1 one

39. 8 ten-thousands + 5 thousands + 7 ones

40. 2 ten-thousands + 6 thousands + 2 ones

41. Name the first four periods of a number (from right to left).

42. Name the first four place values of a number (from right to left).

Concept 3: Writing Numbers in Words

For Exercises 43–50, write the number in words. **(See Example 5.)**

43. 241 **44.** 327 **45.** 603 **46.** 108

47. 31,530 **48.** 52,160 **49.** 100,234 **50.** 400,199

51. The Shuowen jiezi dictionary, an ancient Chinese dictionary that dates back to the year 100, contained 9535 characters. Write 9535 in words.

52. Interstate I-75 is 1377 miles (mi) long. Write 1377 in words.

53. The altitude of Denali in Alaska is 20,310 ft. Write 20,320 in words.

54. There are 1800 seats in a theater. Write 1800 in words.

55. Researchers calculate that about 590,712 stone blocks were used to construct the Great Pyramid. Write 590,712 in words.

56. In the United States, there are approximately 60,000,000 cats living in households. Write 60,000,000 in words.

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For Exercises 57–62, convert the number to standard form. **(See Example 6.)**

57. Six thousand, five

58. Four thousand, four

59. Six hundred seventy-two thousand

60. Two hundred forty-eight thousand

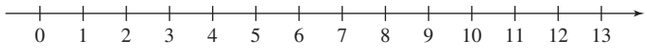
61. One million, four hundred eighty-four thousand, two hundred fifty

62. Two million, six hundred forty-seven thousand, five hundred twenty

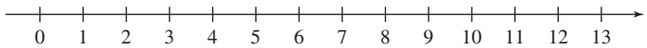
Concept 4: The Number Line and Order

For Exercises 63 and 64, graph the numbers on the number line.

63. **a.** 6 **b.** 13 **c.** 8 **d.** 1



64. **a.** 5 **b.** 3 **c.** 11 **d.** 9



65. On a number line, what number is 4 units to the right of 6?

66. On a number line, what number is 8 units to the left of 11?

67. On a number line, what number is 3 units to the left of 7?

68. On a number line, what number is 5 units to the right of 0?

For Exercises 69–72, translate the inequality to words.

69. $8 > 2$ **70.** $6 < 11$ **71.** $3 < 7$ **72.** $14 > 12$

For Exercises 73–84, fill in the blank with the inequality symbol $<$ or $>$. **(See Example 7.)**

73. $6 \square 11$ **74.** $14 \square 13$ **75.** $21 \square 18$ **76.** $5 \square 7$

77. $3 \square 7$ **78.** $14 \square 24$ **79.** $95 \square 89$ **80.** $28 \square 30$

81. $0 \square 3$ **82.** $8 \square 0$ **83.** $90 \square 91$ **84.** $48 \square 47$

Expanding Your Skills

85. Answer true or false. 12 is a digit.

86. Answer true or false. 26 is a digit.

87. What is the greatest two-digit number?

88. What is the greatest three-digit number?

89. What is the greatest whole number?

90. What is the least whole number?

91. How many zeros are there in the number ten million?

92. How many zeros are there in the number one hundred billion?

93. What is the greatest three-digit number that can be formed from the digits 6, 9, and 4? Use each digit only once.

94. What is the greatest three-digit number that can be formed from the digits 0, 4, and 8? Use each digit only once.

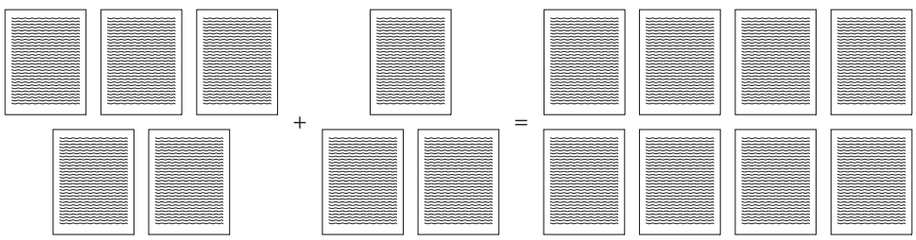
Section 1.3 Addition and Subtraction of Whole Numbers and Perimeter

Concepts

1. Addition of Whole Numbers

We use addition of whole numbers to represent an increase in quantity. For example, suppose Jonas typed 5 pages of a report before lunch. Later in the afternoon he typed 3 more pages. The total number of pages that he typed is found by adding 5 and 3.

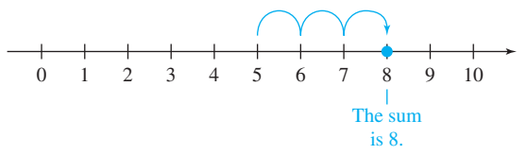
5 pages + 3 pages = 8 pages



The result of an addition problem is called the **sum**, and the numbers being added are called **addends**. Thus,

$$\underset{\text{addends}}{5 + 3} = \underset{\text{sum}}{8}$$

The number line is a useful tool to visualize the operation of addition. To add 5 and 3 on a number line, begin at 5 and move 3 units to the right. The final location indicates the sum.



You can use a number line to find the sum of any pair of digits. The sums for all possible pairs of one-digit numbers should be memorized (see Exercise 7). Memorizing these basic addition facts will make it easier for you to add larger numbers.

To add whole numbers with several digits, line up the numbers vertically by place value. Then add the digits in the corresponding place positions.

Example 1 **Adding Whole Numbers**

Add. $261 + 28$

Solution:

$$\begin{array}{r} 261 \\ +\ 28 \\ \hline 289 \end{array}$$

Add digits in ones column.
Add digits in tens column.
Add digits in hundreds column.

Skill Practice Add.

1. $4135 + 210$

Sometimes when adding numbers, the sum of the digits in a given place position is greater than 9. If this occurs, we must do what is called *carrying* or *regrouping*. Example 2 illustrates this process.

Example 2 Adding Whole Numbers with Carrying

Add. $35 + 48$

Solution:

$$\begin{array}{r} 35 = 3 \text{ tens} + 5 \text{ ones} \\ +\,48 = 4 \text{ tens} + 8 \text{ ones} \\ \hline 7 \text{ tens} + 13 \text{ ones} \end{array}$$

← The sum of the digits in the ones place exceeds 9. But 13 ones is the same as 1 ten and 3 ones. We can *carry* 1 ten to the tens column while leaving the 3 ones in the ones column. Notice that we placed the carried digit above the tens column.

$$\begin{array}{r} \overset{1}{35} = \overset{1\ \text{ten}}{3} \text{ tens} + 5 \text{ ones} \\ +\,48 = 4 \text{ tens} + 8 \text{ ones} \\ \hline 83 = 8 \text{ tens} + 3 \text{ ones} \end{array}$$

The sum is 83.

Skill Practice Add.

2. $43 + 29$

Addition of numbers may include more than two addends.

Example 3 Adding Whole Numbers

Add. $21{,}076 + 84{,}158 + 2419$

Solution:

$$\begin{array}{r} 21{,}\overset{1\,2}{0}76 \\ 84{,}158 \\ +\ 2{,}419 \\ \hline 107{,}653 \end{array}$$

In this example, the sum of the digits in the ones column is 23. Therefore, we write the 3 and carry the 2.

In the tens column, the sum is 15. Write the 5 in the tens place and carry the 1.

Skill Practice Add.

3.
$$\begin{array}{r} 57{,}296 \\ 4{,}089 \\ +\ 9{,}762 \\ \hline \end{array}$$

Answers

1. 4345 **2.** 72 **3.** 71,147

2. Properties of Addition

A **variable** is a letter or symbol that represents a number. The following are examples of variables: a, b, and c. We will use variables to present three important properties of addition.

Most likely you have noticed that 0 added to any number is that number. For example:

$$6 + 0 = 6 \qquad 527 + 0 = 527 \qquad 0 + 88 = 88 \qquad 0 + 15 = 15$$

In each example, the number in red can be replaced with any number that we choose, and the statement would still be true. This fact is stated as the addition property of 0.

Addition Property of 0

For any number a,

$$a + 0 = a \quad \text{and} \quad 0 + a = a$$

The sum of any number and 0 is that number.

The order in which we add two numbers does not affect the result. For example: $11 + 20 = 20 + 11$. This is true for any two numbers and is stated in the next property.

Commutative Property of Addition

For any numbers a and b,

$$a + b = b + a$$

Changing the order of two addends does not affect the sum.

In mathematics we use parentheses ( ) as grouping symbols. To add more than two numbers, we can group them and then add. For example:

$$\begin{aligned} &(2 + 3) + 8 \\ &= 5 + 8 \\ &= 13 \end{aligned}$$

Parentheses indicate that $2 + 3$ is added first. Then 8 is added to the result.

$$\begin{aligned} &2 + (3 + 8) \\ &= 2 + 11 \\ &= 13 \end{aligned}$$

Parentheses indicate that $3 + 8$ is added first. Then the result is added to 2.

Associative Property of Addition

For any numbers a, b, and c,

$$(a + b) + c = a + (b + c)$$

The manner in which addends are grouped does not affect the sum.

Example 4 **Applying the Properties of Addition**

a. Rewrite $9 + 6$, using the commutative property of addition.

b. Rewrite $(15 + 9) + 5$, using the associative property of addition.

Solution:

a. $9 + 6 = 6 + 9$ Change the order of the addends.

b. $(15 + 9) + 5 = 15 + (9 + 5)$ Change the grouping of the addends.

Skill Practice

4. Rewrite $3 + 5$, using the commutative property of addition.

5. Rewrite $(1 + 7) + 12$, using the associative property of addition.

3. Subtraction of Whole Numbers

Jeremy bought a case of 12 sodas, and on a hot afternoon he drank 3 of the sodas. We can use the operation of subtraction to find the number of sodas remaining.

12 sodas − 3 sodas = 9 sodas

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The symbol "−" between two numbers is a subtraction sign, and the result of a subtraction is called the **difference**. The number being subtracted (in this case, 3) is called the **subtrahend**. The number 12 from which 3 is subtracted is called the **minuend**.

$12 - 3 = 9$ is read as "12 minus 3 is equal to 9"

minuend subtrahend difference

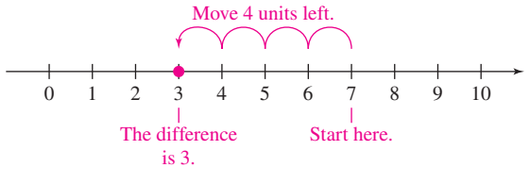
Subtraction is the reverse operation of addition. To find the number of sodas that remain after Jeremy takes 3 sodas away from 12 sodas, we ask the question:

"3 added to what number equals 12?"

That is,

$12 - 3 = ?$ is equivalent to $? + 3 = 12$

Subtraction can also be visualized on the number line. To evaluate $7 - 4$, start from the point on the number line corresponding to the minuend (7 in this case). Then move to the *left* 4 units. The resulting position on the number line is the difference.



Answers

4. $3 + 5 = 5 + 3$

5. $(1 + 7) + 12 = 1 + (7 + 12)$

To check the result, we can use addition.

$$7 - 4 = 3 \quad \text{because} \quad 3 + 4 = 7$$

Example 5 Subtracting Whole Numbers

Subtract and check the answer by using addition.

a. $8 - 2$ **b.** $10 - 6$ **c.** $5 - 0$ **d.** $3 - 3$

Solution:

a. $8 - 2 = 6$ because $6 + 2 = 8$ **b.** $10 - 6 = 4$ because $4 + 6 = 10$

c. $5 - 0 = 5$ because $5 + 0 = 5$ **d.** $3 - 3 = 0$ because $0 + 3 = 3$

Skill Practice Subtract. Check by using addition.

6. $11 - 5$ **7.** $8 - 0$ **8.** $7 - 2$ **9.** $5 - 5$

When subtracting large numbers, it is usually more convenient to write the numbers vertically. We write the minuend on top and the subtrahend below it. Starting from the ones column, we subtract digits having corresponding place values.

Example 6 Subtracting Whole Numbers

Subtract and check the answer by using addition.

a. $\begin{array}{r} 976 \\ -\ 124 \\ \hline \end{array}$ **b.** $\begin{array}{r} 2498 \\ -\ 197 \\ \hline \end{array}$

Solution:

a. $\begin{array}{r} 976 \\ -\ 124 \\ \hline 852 \end{array}$ Check: $\begin{array}{r} 852 \\ +\ 124 \\ \hline 976 \end{array}$ ✓

Subtract the ones column digits.
Subtract the tens column digits.
Subtract the hundreds column digits.

b. $\begin{array}{r} 2498 \\ -\ 197 \\ \hline 2301 \end{array}$ Check: $\begin{array}{r} 2301 \\ +\ 197 \\ \hline 2498 \end{array}$ ✓

Skill Practice Subtract. Check by using addition.

10. $\begin{array}{r} 472 \\ -\ 261 \\ \hline \end{array}$ **11.** $\begin{array}{r} 3947 \\ -\ 137 \\ \hline \end{array}$

Answers

6. 6 **7.** 8 **8.** 5 **9.** 0
10. 211 **11.** 3810

When a digit in the subtrahend (bottom number) is larger than the corresponding digit in the minuend (top number), we must "regroup" or borrow a value from the column to the left.

$$\begin{array}{r} 92 = 9 \text{ tens} + 2 \text{ ones} \\ -\ 74 = 7 \text{ tens} + 4 \text{ ones} \\ \hline \end{array}$$

In the ones column, we cannot take 4 away from 2. We will regroup by borrowing 1 ten from the minuend. Furthermore, 1 ten = 10 ones.

$$\begin{array}{r} \overset{8+10}{\cancel{9}}\ 2 = \overset{8}{\cancel{9}} \text{ tens} + 2 + 10 \text{ ones} \\ -\ 7\ \ 4 = 7 \text{ tens} + 4 \text{ ones} \\ \hline \end{array}$$

We now have 12 ones in the minuend.

$$\begin{array}{r} \overset{8}{\cancel{9}}\ \overset{12}{\cancel{2}} = \overset{8}{\cancel{9}} \text{ tens} + 12 \text{ ones} \\ -\ 7\ 4 = 7 \text{ tens} + 4 \text{ ones} \\ \hline 1\ 8 = 1 \text{ ten} + 8 \text{ ones} \end{array}$$

TIP: The process of *borrowing* in subtraction is the reverse operation of *carrying* in addition.

Example 7 Subtracting Whole Numbers with Borrowing

Subtract and check the result with addition.

$$\begin{array}{r} 134{,}616 \\ -\ 53{,}438 \\ \hline \end{array}$$

Solution:

$$\begin{array}{r} 1\ 3\ 4,\ 6\ \overset{0}{\cancel{1}}\ \overset{16}{\cancel{6}} \\ -\ 5\ 3,\ 4\ 3\ 8 \\ \hline 8 \end{array}$$

In the ones place, 8 is greater than 6. We borrow 1 ten from the tens place.

$$\begin{array}{r} 1\ 3\ 4,\ \overset{5}{\cancel{6}}\ \overset{10}{\cancel{1}}\ \overset{16}{\cancel{6}} \\ -\ 5\ 3,\ 4\ 3\ 8 \\ \hline 7\ 8 \end{array}$$

In the tens place, 3 is greater than 0. We borrow 1 hundred from the hundreds place.

$$\begin{array}{r} \overset{0}{\cancel{1}}\ \overset{13}{\cancel{3}}\ 4,\ \overset{5}{\cancel{6}}\ \overset{10}{\cancel{1}}\ \overset{16}{\cancel{6}} \\ -\ 5\ 3,\ 4\ 3\ 8 \\ \hline 8\ 1,\ 1\ 7\ 8 \end{array}$$

In the ten-thousands place, 5 is greater than 3. We borrow 1 hundred-thousand from the hundred-thousands place.

Check:

$$\begin{array}{r} \overset{1\ 1}{81{,}178} \\ +\ 53{,}438 \\ \hline 134{,}616\ \checkmark \end{array}$$

Skill Practice Subtract. Check by addition.

12.
$$\begin{array}{r} 23{,}126 \\ -\ 6{,}048 \\ \hline \end{array}$$

Answer

12. 17,078

Example 8 **Subtracting Whole Numbers with Borrowing**

Subtract and check the result with addition. $500 - 247$

Solution:

$$\begin{array}{r} 500 \\ -\ 247 \end{array}$$

In the ones place, 7 is greater than 0. We try to borrow 1 ten from the tens place. However, the tens place digit is 0. Therefore we must first borrow from the hundreds place.

$$\begin{array}{r} {\scriptstyle 4\ \ 10} \\ \not{5}\ \not{0}\ 0 \\ -\ 2\ 4\ 7 \end{array}$$

← 1 hundred = 10 tens

$$\begin{array}{r} {\scriptstyle 4\ \ 9\ \ 10} \\ \not{5}\ \not{0}\ \not{0} \\ -\ 2\ 4\ 7 \\ \hline 2\ 5\ 3 \end{array}$$

← Now we can borrow 1 ten to add to the ones place.

Subtract.

Check:
$$\begin{array}{r} {\scriptstyle 1\ 1} \\ 253 \\ +\ 247 \\ \hline 500\ \checkmark \end{array}$$

Skill Practice Subtract. Check by addition.

13. $700 - 531$

4. Translations and Applications Involving Addition and Subtraction

In the English language, there are many different words and phrases that imply addition. A partial list is given in Table 1-1.

Table 1-1

Word/Phrase	Example	In Symbols
Sum	The sum of 6 and x	$6 + x$
Added to	3 added to 8	$8 + 3$
Increased by	y increased by 2	$y + 2$
More than	10 more than 6	$6 + 10$
Plus	8 plus 3	$8 + 3$
Total of	The total of a and b	$a + b$

Example 9 **Translating an English Phrase to a Mathematical Statement**

Translate each phrase to an equivalent mathematical statement and simplify.

a. 12 added to 109

b. The sum of 1386 and 376

Answer
13. 169

Solution:

a. $109 + 12$

$$\begin{array}{r} {\scriptstyle 1} \\ 109 \\ +\ 12 \\ \hline 121 \end{array}$$

b. $1386 + 376$

$$\begin{array}{r} {\scriptstyle 1\,1} \\ 1386 \\ +\ 376 \\ \hline 1762 \end{array}$$

Skill Practice Translate and simplify.

14. 50 more than 80 **15.** 12 increased by 14

Table 1-2 gives several key phrases that imply subtraction.

Table 1-2

Word/Phrase	Example	In Symbols
Minus	15 minus x	$15 - x$
Difference	The difference of 10 and 2	$10 - 2$
Decreased by	a decreased by 1	$a - 1$
Less than	5 less than 12	$12 - 5$
Subtract . . . from	Subtract 3 from 8	$8 - 3$
Subtracted from	6 subtracted from 10	$10 - 6$

In Table 1-2, make a note of the last three entries. The phrases *less than*, *subtract . . . from* and *subtracted from* imply a specific order in which the subtraction is performed. In all three cases, begin with the second number listed and subtract the first number listed.

Example 10 **Translating an English Phrase to a Mathematical Statement**

Translate the English phrase to a mathematical statement and simplify.

a. The difference of 150 and 38 **b.** 30 subtracted from 82

Solution:

a. From Table 1-2, the *difference* of 150 and 38 implies $150 - 38$.

$$\begin{array}{r} {\scriptstyle 4\ 10} \\ 1\not{5}0 \\ -\ 38 \\ \hline 112 \end{array}$$

b. The phrase "30 subtracted from 82" implies that 30 is taken away from 82. We have $82 - 30$.

$$\begin{array}{r} 82 \\ -\ 30 \\ \hline 52 \end{array}$$

Skill Practice Translate the English phrase to a mathematical statement and simplify.

16. Twelve decreased by eight **17.** Subtract three from nine.

We noted earlier that addition is commutative. That is, the order in which two numbers are added does not affect the sum. This is *not* true for subtraction. For example, $82 - 30$ is not equal to $30 - 82$. The symbol $\neq$ means "is not equal to." Thus, $82 - 30 \neq 30 - 82$.

Answers

14. $80 + 50$; 130 **15.** $12 + 14$; 26
16. $12 - 8$; 4 **17.** $9 - 3$; 6

In Examples 11 and 12, we use addition and subtraction of whole numbers to solve application problems.

Example 11 Solving an Application Problem Involving a Table

The table gives the number of gold, silver, and bronze medals won in a recent Winter Olympics for selected countries.

	Gold	Silver	Bronze
Germany	10	13	7
USA	9	15	13
Canada	14	7	5

a. Find the total number of medals won by Canada.

b. Determine the total number of silver medals won by these three countries.

Solution:

a. The number of medals won by Canada appears in the last row of the table. The word "total" implies addition.

$14 + 7 + 5 = 26$ Canada won 26 medals.

b. The number of silver medals is given in the middle column. The total is

$13 + 15 + 7 = 35$ There were 35 silver medals won by these countries.

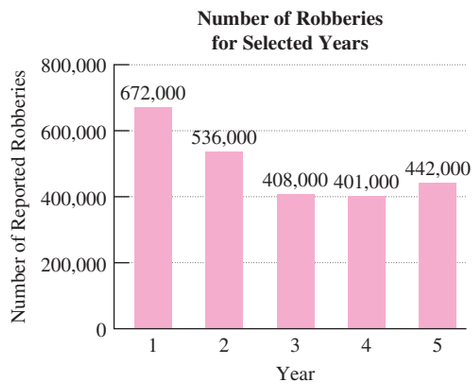
Skill Practice Refer to the table in Example 11.

18. a. Find the total number of bronze medals won.

b. Find the number of medals won by the United States.

Example 12 Solving an Application Problem

A criminal justice student did a study of the number of robberies that occurred in the United States over a period of several years. The graph shows his results for five selected years.



Source: Federal Bureau of Investigation

a. Find the increase in the number of reported robberies from year 4 to year 5.

b. Find the decrease in the number of reported robberies from year 1 to year 2.

Solution:

For the purpose of finding an amount of increase or decrease, we will subtract the smaller number from the larger number.

a. Because the number of robberies went *up* from year 4 to year 5, there was an *increase*. To find the amount of increase, subtract the smaller number from the larger number.

$$\begin{array}{r} 442,000 \\ -\ 401,000 \\ \hline 41,000 \end{array}$$

From year 4 to year 5, there was an increase of 41,000 reported robberies in the United States.

Answer

18. a. 25 medals **b.** 37 medals

b. Because the number of robberies went *down* from year 1 to year 2, there was a *decrease*. To find the amount of decrease, subtract the smaller number from the larger number.

$$\begin{array}{r} {}^{6}6\,{}^{12}\!\not{7}\,2,000 \\ -\,536,000 \\ \hline 136,000 \end{array}$$

From year 1 to year 2, there was a decrease of 136,000 reported robberies in the United States.

Skill Practice Refer to the graph for Example 12.

19. a. Has the number of robberies increased or decreased from year 2 to year 5?

b. Determine the amount of increase or decrease.

5. Perimeter

One special application of addition is to find the perimeter of a polygon. A **polygon** is a flat closed figure formed by line segments connected at their ends. Familiar figures such as triangles, rectangles, and squares are examples of polygons. See Figure 1-3.

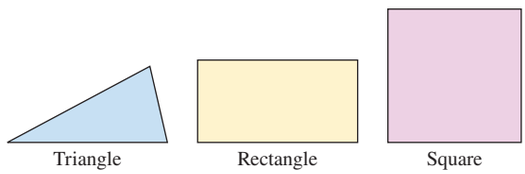
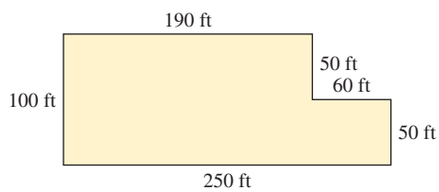


Figure 1-3

The **perimeter** of any polygon is the distance around the outside of the figure. To find the perimeter, add the lengths of the sides.

Example 13 Finding Perimeter

A paving company wants to edge the perimeter of a parking lot with concrete curbing. Find the perimeter of the parking lot.



Solution:

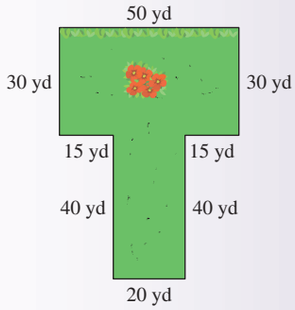
The perimeter is the sum of the lengths of the sides.

$$\begin{array}{r} {}^{3}1\,90 \text{ ft} \\ 50 \text{ ft} \\ 60 \text{ ft} \\ 50 \text{ ft} \\ 250 \text{ ft} \\ +\,100 \text{ ft} \\ \hline 700 \text{ ft} \end{array}$$

The distance around the parking lot (the perimeter) is 700 ft.

Skill Practice

20. Find the perimeter of the garden.



Answers

19. a. decreased **b.** 94,000 robberies
20. 240 yd

Section 1.3 Practice Exercises

Study Skills Exercise

It is very important to attend class every day. Math is cumulative in nature, and you must master the material learned in the previous class to understand the lesson for the next day. Because this is so important, many instructors tie attendance to the final grade. Write down the attendance policy for your class.

Vocabulary and Key Concepts

1. a. The numbers being added in an addition problem are called the _____.

b. The result of an addition problem is called the _____.

c. A _____ is a letter or symbol that represents a number.

d. The _____ property of addition states that the order in which two numbers are added does not affect the sum.

e. For any number a, the addition property of 0 states that $a + 0 =$ ___ and that $0 + a =$ ___.

f. The associative property of addition states that $(a + b) + c =$ _____. This implies that the manner in which addends are grouped under addition does not affect the sum.

g. Given the subtraction statement $15 - 4 = 11$, the number 15 is called the _____, the number 4 is called the _____, and the number 11 is called the _____.

h. A _____ is a flat closed figure formed by line segments connected at their ends.

i. The _____ of a polygon is the sum of the lengths of the sides.

Review Exercises

For Exercises 2–6, write the number in the form indicated.

2. Write 5,024 in expanded form.

3. Write 351 in expanded form.

4. Write in standard form: two thousand, four

5. Write in standard form: four thousand, twelve

6. Write in standard form: 6 thousands + 2 hundreds + 6 ones

Concept 1: Addition of Whole Numbers

7. Fill in the table.

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

For Exercises 8–10, identify the addends and the sum.

8. $11 + 10 = 21$ **9.** $1 + 13 + 4 = 18$ **10.** $5 + 8 + 2 = 15$

For Exercises 11–18, add. **(See Example 1.)**

11. $\begin{array}{r} 42 \\ +\ 33 \\ \hline \end{array}$ **12.** $\begin{array}{r} 21 \\ +\ 53 \\ \hline \end{array}$ **13.** $\begin{array}{r} 12 \\ 15 \\ +\ 32 \\ \hline \end{array}$ **14.** $\begin{array}{r} 10 \\ 8 \\ +\ 30 \\ \hline \end{array}$

15. $890 + 107$ **16.** $444 + 354$ **17.** $4 + 13 + 102$ **18.** $11 + 221 + 5$

For Exercises 19–32, add the whole numbers with carrying. **(See Examples 2 and 3.)**

19. $\begin{array}{r} 76 \\ +\ 45 \\ \hline \end{array}$ **20.** $\begin{array}{r} 25 \\ +\ 59 \\ \hline \end{array}$ **21.** $\begin{array}{r} 87 \\ +\ 24 \\ \hline \end{array}$ **22.** $\begin{array}{r} 38 \\ +\ 77 \\ \hline \end{array}$

23. $\begin{array}{r} 658 \\ +\ 231 \\ \hline \end{array}$ **24.** $\begin{array}{r} 642 \\ +\ 295 \\ \hline \end{array}$ **25.** $\begin{array}{r} 152 \\ +\ 549 \\ \hline \end{array}$ **26.** $\begin{array}{r} 462 \\ +\ 388 \\ \hline \end{array}$

27. $79 + 112 + 12$ **28.** $62 + 907 + 34$ **29.** $4980 + 10{,}223$ **30.** $23{,}112 + 892$

31. $10{,}223 + 25{,}782 + 4980$ **32.** $92{,}377 + 5622 + 34{,}659$

Concept 2: Properties of Addition

For Exercises 33–36, rewrite the addition problem, using the commutative property of addition. **(See Example 4.)**

33. $101 + 44 = \square + \square$ **34.** $8 + 13 = \square + \square$ **35.** $x + y = \square + \square$ **36.** $t + q = \square + \square$

For Exercises 37–40, rewrite the addition problem using the associative property of addition, by inserting a pair of parentheses. **(See Example 4.)**

37. $(23 + 9) + 10 = 23 + 9 + 10$ **38.** $7 + (12 + 8) = 7 + 12 + 8$

39. $r + (s + t) = r + s + t$ **40.** $(c + d) + e = c + d + e$

41. Explain the difference between the commutative and associative properties of addition.

42. Explain the addition property of 0. Then simplify the expressions.

a. $423 + 0$ **b.** $0 + 25$ **c.** $\begin{array}{r} 67 \\ +\ 0 \\ \hline \end{array}$ **d.** $0 + x$

Concept 3: Subtraction of Whole Numbers

For Exercises 43 and 44, identify the minuend, subtrahend, and the difference.

43. $12 - 8 = 4$ **44.** $\begin{array}{r} 9 \\ -\ 6 \\ \hline 3 \end{array}$

For Exercises 45–48, write the subtraction problem as a related addition problem. For example, $19 - 6 = 13$ can be written as $13 + 6 = 19$.

45. $27 - 9 = 18$ **46.** $20 - 8 = 12$ **47.** $102 - 75 = 27$ **48.** $211 - 45 = 166$