The ninth edition of *Topics in Contemporary Mathematics* contains a wide variety of features designed to build the reader’s understanding of mathematics by connecting the material to real-life concepts. This edition builds on the successful pedagogy of previous editions and includes several features intended to connect the material to the lives of today’s students.

Students who utilize these features will gain a better understanding of the history behind each topic, how the topic relates to everyday life, how different topics in the course interrelate, and—most important—how to approach problem solving in the real world once they complete the course.

**Chapter Opening Features**

- **Chapter Opening Preview**
  Each chapter begins with a list of section topics for quick reference. The introduction that follows provides an overview of the material presented and explains the ways in which topics are related throughout the chapter. Each chapter-opening photo is directly related to one of the *Getting Started* features in the chapter.

- **Internet Connection**
  A student-friendly Web site supports the new edition. A comprehensive set of annotated links for the section and topics in each chapter provides students with access to additional information, practice problems, tutorials, and downloadable software. Material supported on the Online Study Center is identified by an icon throughout the text.

**Chapter 7**

**Functions and Graphs**

In Chapter 6 we studied first- and second-degree equations with one variable. In this chapter we shall study similar equations with two variables. The main feature here, however, is an introduction to some simple ideas that belong to the area that is called *analytic geometry*, a blend of algebra and geometry in which algebra is used to study geometry and geometry is used to study algebra. The key to this combination is a workable system of associating points in the plane with ordered pairs of numbers.

We start the chapter by studying sets of ordered pairs called *relations*, concentrating on a special type of relation called a *function*. We examine function notation and how to represent relations and functions by means of *graphs*. We also study the formulas giving the distance between any two points in the Cartesian plane and the slope (inclination) of a line passing through those two points. We explore the ways to write the equations of a line depending on the information that is given and the ways to solve systems of linear equations with two unknowns by using algebraic or graphical methods.
### Human Side of Math

Brief biographies of those who devised or contributed to the development of the mathematics covered in the chapter appear at the beginning of each chapter in the Human Side of Math margin feature. Looking Ahead links the biographies to the upcoming material. This feature communicates that mathematics is a growing body of knowledge and a human endeavor, and that every topic studied began as part of a problem-solving process.

### Getting Started

Every section begins with a Getting Started application that demonstrates how the material relates to the real world. Where appropriate, this application is revisited as a Collaborative Learning exercise in the section exercise set.
Problem Solving
Problem solving is introduced in Chapter 1 and presented as an ongoing theme. Specific Problem Solving examples are formatted using the RSTUV method (Read, Select, Think, Use, and Verify) to guide the reader through the problem. The solution is carefully developed to the right of the problem-solving steps. Students are encouraged to cover the solution, write their own solutions, and check their work in order to build problem-solving skills. This feature also includes references to similar problems in the exercise sets.

Word Problems
When fully loaded, a space shuttle and its payload (cargo) weigh about 215,000 lb. The shuttle itself weighs 85,000 lb more than the payload. What is the weight of each?

The problem asks for the weight of each, that is, the weight of the shuttle and the weight of the payload. Let $p$ represent the weight of the payload in pounds. Since the shuttle weighs 85,000 lb more than the payload, the shuttle weight $p + 85,000$ lb.

Translate the first sentence in the problem into an algebraic statement.

The shuttle and its payload weigh 215,000 lb.

This is a verbal model for the problem. This is an algebraic model for the problem.

Thus, the payload weighs 65,000 lb, and the shuttle weighs $65,000 + 85,000 = 150,000$ lb.

To verify the answer, note that the combined weight of the shuttle and its payload is $150,000 + 65,000 = 215,000$ lb, as stated in the problem.

Cover the solution, write your own solution, and then check your work.

EXAMPLE 1 Modeling and Interest
Angie bought a 6-month, $10,000 certificate of deposit. At the end of the 6 months, she received $650 simple interest. What rate of interest did the certificate pay?

Solution
1. Read the problem. It asks for the rate of simple interest.
2. Select the variable $r$ to represent this rate.

3. Translate the first sentence in the problem into an algebraic statement.

$650$ is the amount of interest, $P$ is the principal, $r$ is the interest rate, and $t$ years. For our problem, $t = 6/12$, $P = 10,000$, $r$ is unknown, or $1$. Thus, we have

$650 = (10,000)(r)(6/12)$

or $500r = 650$.

Using this idea, $500r = 650$. To solve for $r$, divide both sides of the equation by 500.

$r = 650/500 = 1.3$

The solution is $1.3$, or $130/100$ or $13/10$ or $13\%$.

The rate of simple interest Angie received is $13\%$.

B. Solving Quadratic Equations by Factoring
The next examples show how factoring can sometimes be used to solve quadratic equations.

EXAMPLE 3 Solving Quadratics by Factoring
Solve the following equations:

(a) $x^2 + 3x + 2 = 0$
(b) $5x^2 - 14x = 3$

Solution
(a) We have already shown that $x^2 + 3x + 2 = (x + 2)(x + 1)$. Thus,

$$x^2 + 3x + 2 = 0$$

With one term on one side, we can make use of the property of the real number system that says that a product of two real numbers is 0 if and only if at least one of them is 0. Thus, the preceding equation is true if and only if

$$x + 2 = 0$$

or

$$x + 1 = 0$$

They are solutions to the equation.

The solution set of the given equation is $\{-2, -1\}$.

Check: By substitution in the left side of the given equation, we find for $x = -3$, $x^2 + 3x + 2 = (-3)^2 + 3(-3) + 2 = 9 - 9 + 2 = 2$. Thus, the solution $x = -3$.

For $x = -2$, we get $x^2 + 3x + 2 = (-2)^2 + 3(-2) + 2 = 4 - 6 + 2 = 0$, which checks the solution $x = -2$.

(b) Subtract 3 from both sides of the equation to obtain

$$5x^2 - 14x = 3$$

The positive factors of 5 are 5 and 1, whereas the factors of $-3$ are $-3$, $1$ or $1$, $-3$. Thus,

$$5x^2 - 14x = 3(x + 1)(x - 3) = 0$$

Hence,

$$5x + 1 = 0$$

or

$$x - 3 = 0$$

That is,

$$x = -1$$

or

$$x = 3$$

Therefore, the solution set of $5x^2 - 14x = 3$ is $\{1, 3\}$. Make sure that you check that the solution is correct!
Web It
The Web It feature directs students to the Web site link they need to access for further exploration, tools, or practice. Students can use the Internet to help them connect the mathematics under discussion to their daily lives. In later chapters, selected exercise sets conclude with optional Web It Exercises that require the use of the Internet as part of the problem-solving process.

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Solving Systems of Linear Equations with Matrices

### Exercises 9.2

**Solution by Matrices**

1. \(x + y - z = 3\) \(x + 2y + z = 5\) \(2x + y + 2z = 4\)  
2. \(x + y - z = -3\) \(2x + y + 2z = 4\) \(3x - 2y + z = -1\)  
3. \(2x - y + 2z = 5\) \(x + 2y - z = 0\) \(2x + y - z = -6\)  
4. \(3x + 2y + z = -5\) \(4x + 3y - z = 12\) \(2x - y + 3z = 3\)  
5. \(3x + 2y - z = 5\) \(2x - y + 3z = -10\) \(2x + y - z = -4\)  
6. \(x + y + z = 3\) \(x - y + 2z = -3\) \(z = 1\)  
7. \(x + y + z = 3\) \(x - 2y + 3z = 5\) \(x + y + z = 3\)  
8. \(x + y + z = 3\) \(x - 2y + 3z = 5\) \(x - y - z = 1\)  
9. Show that elementary operation 3 yields an equivalent system. (Hint: Consider the first two equations of system (1) in the text. Show that if \(a, b, c, d\) satisfies both these equations, then it satisfies the system consisting of the first equation and the sum of the first two equations, and conversely.)

**Applications**

10. The sum of $8.50 is made up of nickels, dimes, and quarters. The number of dimes is equal to the number of quarters plus twice the number of nickels. The value of the dimes exceeds the combined value of the nickels and the quarters by $1.50. How many of each coin are there?

11. The Mechano Distributing Company has three types of vending machines that dispense snacks as listed in the table below. Mechano fills all the machines once a day and finds them all sold out before the next day. The total daily sales are candy, 760; peanuts, 380; and sandwiches, 660. How many of each type of machine does Mechano have?

<table>
<thead>
<tr>
<th>Snack</th>
<th>Type I</th>
<th>Type II</th>
<th>Type III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Candy</td>
<td>20</td>
<td>15</td>
<td>10</td>
</tr>
<tr>
<td>Peanuts</td>
<td>30</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>Sandwiches</td>
<td>0</td>
<td>30</td>
<td>30</td>
</tr>
</tbody>
</table>

12. Show that the equation \(x = 1\) is compatible with the given system.

13. The 300 students of a high school are divided into three groups. Group A consists of 120 students, Group B of 130 students, and Group C of 50 students. Each student in Group A is a member of Group B, each student in Group B is a member of Group C, and each student in Group C is a member of Group A.

### Summary

- Regions in Monge's and related coordinate systems:
  - \(R_1\) consists of the points \((x, y, z)\) such that \(x = 0\)
  - \(R_2\) consists of the points \((x, y, z)\) such that \(y = 0\)
  - \(R_3\) consists of the points \((x, y, z)\) such that \(z = 0\)

### Exercises

- **Exercises:** The exercises are appropriately graded and represent a wide range of computational, drill, and applied problems. The end-of-section exercise sets are keyed to the corresponding subsection heads (A, B, C, etc.) within each section to help students make connections between subsection presentation and the exercises. The subsection heads serve as a useful reference tool.

- **Using Your Knowledge:** Using Your Knowledge exercises are interesting application problems included throughout the exercise sets. These application problems help students generalize material they have learned and help them to apply it to similar real-life situations.
Discovery

These brief excursions into related topics, extensions, and generalizations are more challenging problems and provide additional opportunities to develop critical thinking and problem-solving skills.

Calculator Corner

Understanding how and when to utilize technology is an important problem-solving skill. The Calculator Corner feature provides additional background on how to solve problems using a calculator.

41. Find the distance traveled when going from Lasru to San Antonio to Del Rio and back to Laredo.
42. Find the distance traveled when going from Dallas to Houston to Shreveport and back to Dallas.
43. Find the distance traveled when starting at Austin, driving to Ft. Worth, then to Abilene, and then back to Austin.
44. The distance from Tucumcari (New Mexico) to Fort Smith (Arkansas) is about 555 mi. How far is it from Oklahoma City to Fort Smith?

In Other Words

45. Which do you think is the better illustration of a circle: a perfectly round penny or a bicycle tire? (See the definition of a circle.)
46. The formula \( C = 2\pi r \) gives the circumference of a circle in inches. Explain how you would use this formula to find your ring size.
47. If two tires, one new and one worn, are installed on a car, which one will turn more times per mile? Explain your answer.
48. If your calculator has a \( \pi \) key, use it to calculate the answer to problem 30. In your own words, explain the discrepancy between the answer you obtained following the instructions for problem 30 and the new answer on your calculator.

Using Your Knowledge

Suppose that circle \( A \) has a 3-in. circumference and circle \( B \) has a 1-in. circumference, as shown in the left diagram in the figure in the next column. If circle \( B \) rolls around the perimeter of circle \( A \) without slipping and returns to its original position, how many revolutions will it have made? (See the diagram below.) Using your knowledge of circumference, can you prove your case?

49. In the diagram on the left, what is the length of the arc, shown in red?
50. If circle \( B \) makes one revolution and ends as shown in the diagram on the right, how far has point \( A \) traveled relative to circle \( B \)?

Collaborative Learning

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42. Find the distance traveled when going from Dallas to Houston to Shreveport and back to Dallas.
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44. The distance from Tucumcari (New Mexico) to Fort Smith (Arkansas) is about 555 mi. How far is it from Oklahoma City to Fort Smith?

In Other Words

51. How far does point \( A \) travel relative to circle \( B \) when point \( A \) makes one complete revolution relative to circle \( B \)?
52. On the basis of your previous answers, what is the number of revolutions it takes for circle \( B \) to make a complete revolution around circle \( A \), whose circumference is 5 in., to return to its original point?

Calculator Corner

Many calculators come equipped with a \( \pi \) key to access \( \pi \). How do you enter \( \pi \) on your calculator?

Collaborative Learning

53. Calculate the circumference of the head of the person.
54. Calculate the circumference of the head of the person using the approximation \( \pi = 3.141592654 \).
55. Which do you think is the better illustration of a circle: a perfectly round penny or a bicycle tire? (See the definition of a circle.)
56. The formula \( C = 2\pi r \) gives the circumference of a circle in inches. Explain how you would use this formula to find your ring size.
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Skill Checker

The Skill Checker feature helps students assess their mastery of the skills that they need in order to proceed to the next section. This feature appears in exercise sets preceding material with relevant prerequisites. Planning and preparing for new material are important aspects of independent and team problem solving.

Research Questions

The Research Questions combined with the In Other Words problems provide a strong writing component to the course and are an excellent opportunity for group learning. The questions appear at the end of selected section exercise sets as well as after each chapter summary. Some questions, identified by icon, require students to utilize the Internet as a research tool.

Chapter 4 Summary

<table>
<thead>
<tr>
<th>Section</th>
<th>Item</th>
<th>Meaning</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1</td>
<td>Egyptian</td>
<td>I</td>
<td>1</td>
</tr>
<tr>
<td>4.2</td>
<td>Babylonian</td>
<td>V</td>
<td>5</td>
</tr>
<tr>
<td>4.3</td>
<td>Roman</td>
<td>X</td>
<td>10</td>
</tr>
<tr>
<td>4.4</td>
<td></td>
<td>L</td>
<td>50</td>
</tr>
<tr>
<td>4.5</td>
<td></td>
<td>C</td>
<td>100</td>
</tr>
<tr>
<td>4.6</td>
<td></td>
<td>D</td>
<td>500</td>
</tr>
<tr>
<td>4.7</td>
<td></td>
<td>M</td>
<td>1000</td>
</tr>
<tr>
<td>4.8</td>
<td></td>
<td>N</td>
<td>10,000</td>
</tr>
<tr>
<td>4.9</td>
<td></td>
<td>P</td>
<td>100,000</td>
</tr>
<tr>
<td>4.10</td>
<td></td>
<td>Q</td>
<td>1 million</td>
</tr>
<tr>
<td>4.11</td>
<td></td>
<td>R</td>
<td>a^n</td>
</tr>
<tr>
<td>4.12</td>
<td></td>
<td>S</td>
<td>a = a × a × ⋯ × a</td>
</tr>
<tr>
<td>4.13</td>
<td></td>
<td>T</td>
<td>10^n = 10 × 10 × ⋯ × 10</td>
</tr>
<tr>
<td>4.14</td>
<td></td>
<td>U</td>
<td>a^m × a^n = a^{m+n}</td>
</tr>
<tr>
<td>4.15</td>
<td></td>
<td>V</td>
<td>(a × b)^n = a^n × b^n</td>
</tr>
<tr>
<td>4.16</td>
<td></td>
<td>W</td>
<td>a^{m/n}</td>
</tr>
<tr>
<td>4.17</td>
<td></td>
<td>X</td>
<td>(a × b)^n = a^n × b^n</td>
</tr>
</tbody>
</table>

Research Questions

- Write a report on the Egyptian numeration system.
- Trace the development of the Babylonian numeration system, with special emphasis on the base used.
- Write a report on the Roman numeration system.
- Write a report on the Mayan calendar. Include the glyphs (graphic symbol or character) used for each day and the length of its months and year. Find information on how to correlate the Gregorian and Mayan calendars.

End-of-Chapter Study Aids

Chapter Summary

The Chapter Summary provides brief definitions and examples for key topics within a given chapter. It also contains section references to encourage students to review sections, rather than memorize a definition out of context. Research Questions are also provided at the end of each chapter summary.
Practice Test

A Practice Test appears at the end of each chapter. The tests are designed to help students check their comprehension and can help to further develop problem-solving and test-taking skills.

Chapter 4 Practice Test

1. Write the following in Egyptian numerals:
   a. 63 b. 735
2. Write the following in decimal notation:
   a. \( \overline{\text{I}} \) b. \( \overline{\text{II}} \)
3. Write the following in Babylonian numerals:
   a. 63 b. 735
4. Write the following in decimal notation:
   a. \( \overline{\text{I}} \) b. \( \overline{\text{II}} \)
5. Do the multiplication \( 23 \times 21 \) using the following:
   a. The Egyptian method of successive duplication
   b. The Egyptian method of mediation and duplication
6. Write the following in decimal notation:
   a. \( \overline{\text{I}} \) b. \( \overline{\text{II}} \)
7. Write the following in Roman numerals:
   a. 53 b. 42 c. 22,000
8. Write the following in decimal notation:
   a. \( 3 \times 10^3 \) b. \( 2 \times 10^3 \)
9. Do the following computations in the usual way and in expanded form:
   a. 75 b. 36
10. Perform the indicated operations, leaving the answers in exponential form:
    a. \( 3^5 \times 3^2 \) b. \( 2^3 \div 2^2 \)
11. Do the following computations in the usual way and in expanded form:
    a. 83 b. 54
12. Change the following to decimal notation:
    a. 203 b. 141
13. Change the following to decimal notation:
    a. 192 b. 143
14. Change the following to decimal notation:
    a. \( 2 \times 10^2 \) b. \( 3 \times 10^2 \)
15. Convert the number 33 to the following:
    a. Base 6 b. Base 7
16. Convert the following to binary notation:
    a. 39 b. 527
17. Convert the number 47 to the following:
    a. Base 6 b. Base 7

Answers to Practice Test

21. Add \( \overline{\text{III}} + 4\overline{\text{II}} \) in the octal system.
22. Multiply \( \overline{\text{III}} \) by \( \overline{\text{II}} \) in the octal system.
23. Subtract \( \overline{\text{III}} \) from \( \overline{\text{III}} \) in the octal system.
24. Divide \( \overline{\text{III}} \) by \( \overline{\text{II}} \) in the octal system.

Answers to Practice Test

The Answers to Practice Test follow immediately after each Practice Test. The answers to each question are keyed to a specific section, example, and page(s) that students should reference if their answer is incorrect. This feature provides students with a means of diagnosing the skills and concepts they have mastered and identifying those that require further work. In addition, the Answers to Practice Test help students to further develop their study skills and assess their mathematical progress.