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SCHNEIDER DANIELS

**COLLEGE ALGEBRA
AND TRIGONOMETRY**

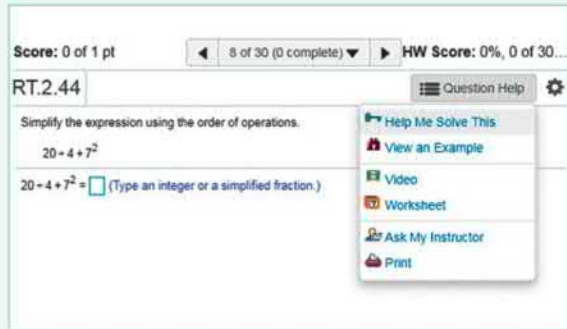


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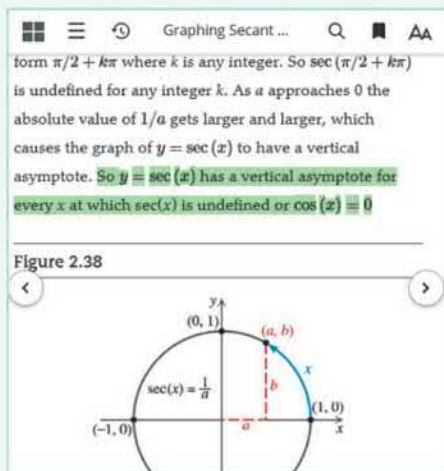
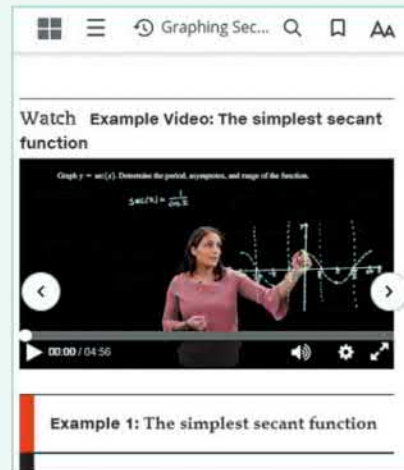


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College Algebra and Trigonometry

SEVENTH EDITION

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College Algebra and Trigonometry

SEVENTH EDITION

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This text is dedicated to you – the student. We hope that it helps you achieve your goals. Remember to show up, work hard, and stay positive. Everything else will take care of itself.

The Lial Author Team

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WELCOME TO THE 7TH EDITION

In the seventh edition of *College Algebra and Trigonometry*, we continue our ongoing commitment to providing the best possible text to help instructors teach and students succeed. In this edition, we have remained true to the pedagogical style of the past while staying focused on the needs of today's students. Support for all classroom types (traditional, corequisite, flipped, hybrid, and online) may be found in this classic text and its supplements backed by the power of Pearson's MyLab Math.

In this edition, we have drawn on the extensive teaching experience of the Lial team, with special consideration given to reviewer suggestions. General updates include enhanced readability as we continually strive to make math understandable for students, updates to our extensive list of applications and real-world mathematics problems, use of color in displays and side comments, and coordination of exercises and their related examples.

The authors understand that teaching and learning mathematics today can be a challenging task. Some students are prepared for the challenge, while other students require more review and supplemental material. This text is written so that students with varying abilities and backgrounds will all have an opportunity for a successful learning experience.

The Lial team believes this to be our best edition of *College Algebra and Trigonometry* yet, and we sincerely hope that you enjoy using it as much as we have enjoyed writing it. Additional textbooks in this series are

College Algebra, Thirteenth Edition
Trigonometry, Twelfth Edition
Precalculus, Seventh Edition.

HIGHLIGHTS OF NEW CONTENT

- **Chapter R** has been expanded to include more of the basic concepts many students struggle with. It begins with new **Section R.1 Fractions, Decimals, and Percents**. Additional new topics have been inserted throughout the chapter, including operations with signed numbers (**Section R.3**), dividing a polynomial by a monomial (**Section R.5**), and factoring expressions with negative and rational exponents (**Section R.6**). Topics throughout the chapter have been reorganized for improved flow.

Instructors may choose to cover review topics from **Chapter R** at the beginning of a course or to insert these topics as-needed in a just-in-time fashion. Either way, students who are under-prepared for the demands of college algebra and trigonometry, as well as those who need a quick review, will benefit from the material contained here.

- The exercise sets were a key focus of this revision, and **Chapters 1 and 2** are among the chapters that have benefitted. Specifically, **Section 1.7 Inequalities** has new exercises on solving quadratic and rational inequalities, and **Section 1.8 Absolute Value Equations and Inequalities** contains new exercises that involve the absolute value of a quadratic polynomial. **Section 2.3 Functions** has new exercises that use analytic methods to determine maximum and minimum values of a function.

Section 2.6 Graphs of Basic Functions contains new exercises and applications using the greatest integer function. **Section 2.4 Linear Functions** includes enhanced discussion of the average rate of change of a linear function. This topic is then related to the difference quotient and the average rate of change of a nonlinear function in **Section 2.8 Function Operations and Composition**.


- **Chapter 3** includes new **Section 3.6 Polynomial and Rational Inequalities**. This section features a visual approach to solving such inequalities by interpreting the graphs of related functions.
- In response to reviewer suggestions, **Section 4.3 Logarithmic Functions** has new exercises that relate exponential and logarithmic functions as inverses. **Chapter 6** includes additional exercises devoted to finding arc length and area of a sector of a circle (**Section 6.1**), as well as new applications of linear and angular speed (**Section 6.2**) and harmonic motion (**Section 6.7**).
- Proofs of identities in **Chapter 7** now feature a drop-down style for increased clarity and student understanding. Based on reviewer requests, **Section 7.7 Equations Involving Inverse Trigonometric Functions** includes new exercises in which solutions of inverse trigonometric equations are found.
- Based on reviewer feedback, **Section 8.4 Algebraically Defined Vectors and the Dot Product** has new exercises on finding the angle between two vectors, determining magnitude and direction angle for a vector, and identifying orthogonal vectors. Additionally, **Chapter 8** contains new exercises requiring students to graph polar and parametric equations (**Section 8.7**) and give parametric representations of plane curves (**Section 8.8**).
- **Section 9.2 Matrix Solution of Linear Systems** now includes a new example and related exercises that use Gaussian elimination to solve linear systems of equations. **Section 10.2 Ellipses** and **Section 10.3 Hyperbolas** include new examples and exercises in which completing the square is used to find the standard form of an ellipse or a hyperbola.

FEATURES OF THIS TEXT

SUPPORT FOR LEARNING CONCEPTS


We provide a variety of features to support students' learning of the essential topics of college algebra and trigonometry. Explanations that are written in understandable terms, figures and graphs that illustrate examples and concepts, graphing technology that supports and enhances algebraic manipulations, and real-life applications that enrich the topics with meaning all provide opportunities for students to deepen their understanding of mathematics. These features help students make mathematical connections and expand their own knowledge base.

- **Examples** Numbered examples that illustrate the techniques for working exercises are found in every section. We use traditional explanations, side comments, and pointers to describe the steps taken—and to warn students about common pitfalls. Some examples provide additional graphing calculator solutions, although these can be omitted if desired.
- **Now Try Exercises** Following each numbered example, the student is directed to try a corresponding odd-numbered exercise (or exercises). This feature allows for quick feedback to determine whether the student understands the principles illustrated in the example.

- **Real-Life Applications** We have included hundreds of real-life applications, many with data updated from the previous edition. They come from fields such as business, entertainment, sports, biology, astronomy, geology, and environmental studies.
- **Function Boxes** Beginning in Chapter 2, functions provide a unifying theme throughout the text. Special function boxes offer a comprehensive, visual introduction to each type of function and also serve as an excellent resource for reference and review. Each function box includes a table of values, traditional and calculator-generated graphs, the domain, the range, and other special information about the function. These boxes are assignable in MyLab Math.
- **Figures and Photos** Today's students are more visually oriented than ever before, and we have updated the figures and photos in this edition to promote visual appeal. Guided Visualizations with accompanying exercises and explorations are available and assignable in MyLab Math.
- **Cautions and Notes** Text that is marked **CAUTION** warns students of common errors, and **NOTE** comments point out explanations that should receive particular attention.
- **Looking Ahead to Calculus** These margin notes offer glimpses of how the topics currently being studied are used in calculus.
- **Use of Graphing Technology** We have integrated the use of graphing calculators where appropriate, although *this technology is completely optional and can be omitted without loss of continuity*. We continue to stress that graphing calculators support understanding but that students must first master the underlying mathematical concepts. Exercises that require the use of a graphing calculator are marked with the icon .

SUPPORT FOR PRACTICING CONCEPTS

This text offers a wide variety of exercises to help students master college algebra and trigonometry. The extensive exercise sets provide ample opportunity for practice and increase in difficulty so that students at every level of understanding are challenged. The variety of exercise types promotes mastery of the concepts and reduces the need for rote memorization.

- **Concept Preview** Each exercise set begins with a group of **CONCEPT PREVIEW** exercises designed to promote understanding of vocabulary and basic concepts of each section. These new exercises are assignable in MyLab Math and provide support, especially for hybrid, online, and flipped courses.
- **Exercise Sets** In addition to traditional drill exercises, this text includes writing exercises, optional graphing calculator exercises , and multiple-choice, matching, true/false, and completion exercises. Those marked *Concept Check* focus on conceptual thinking. *Connecting Graphs with Equations* exercises challenge students to write equations that correspond to given graphs. Video solutions for select problems are available in MyLab Math.
- **Relating Concepts Exercises** Appearing at the end of selected exercise sets, these groups of exercises are designed so that students who work them in numerical order will follow a line of reasoning that leads to an understanding of how various topics and concepts are related. All answers to these exercises appear in the student answer section, and these exercises are assignable in MyLab Math.

SUPPORT FOR REVIEW AND TEST PREP

Ample opportunities for review are found both within the chapters and at the ends of chapters. Quizzes and Summary Exercises, interspersed within chapters, provide a quick assessment of students' understanding of the material presented up to that point in the chapter. Chapter Test Preps provide comprehensive study aids to help students prepare for tests.

- **Quizzes** Students can periodically check their progress with in-chapter quizzes that appear in all chapters, beginning with Chapter 1. All answers, with corresponding section references, appear in the student answer section. These quizzes are assignable in MyLab Math.
- **Summary Exercises** These sets of in-chapter exercises give students the all-important opportunity to work *mixed* review exercises, requiring them to synthesize concepts and select appropriate solution methods.
- **End-of-Chapter Test Prep** Following the final numbered section in each chapter, the Test Prep provides a list of **Key Terms**, a list of **New Symbols** (if applicable), and a two-column **Quick Review** that includes a section-by-section summary of concepts with corresponding examples. This feature concludes with a comprehensive set of **Review Exercises** and a **Chapter Test**. The Test Prep, Review Exercises, and Chapter Test are assignable in MyLab Math.

Get the *most* out of MyLab Math



MyLab Math for College Algebra and Trigonometry 7e (access code required)

MyLab Math is tightly integrated with author style, offering a range of author-created resources, to give students a consistent experience.

Preparedness

Preparedness is one of the biggest challenges in many math courses. Pearson offers a variety of content and course options to support students with just-in-time remediation and key-concept review as needed.

Integrated Review in MyLab Math

Integrated Review can be used in corequisite courses or simply to help students who enter a course without a full understanding of prerequisite skills and concepts. Premade, editable Integrated Review assignments are available to assign in the Assignment Manager. Integrated Review landing pages (shown below) are visible by default at the start of most chapters, providing objective-level review.

- Students begin each chapter by completing a Skills Check to pinpoint which topics, if any, they need to review.

- Personalized review homework provides extra support for students who need it on just the topics they didn't master in the preceding Skills Check.



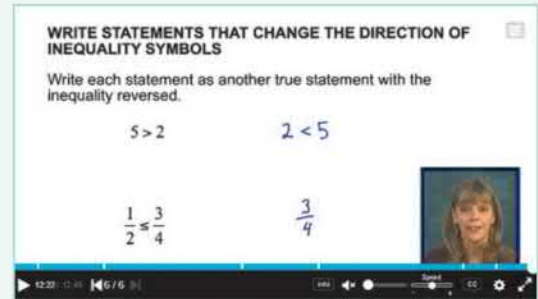
- Additional review materials, including worksheets and videos, are available.

Get the *most* out of MyLab Math



Updated! Videos

Updated videos cover all topics in the text to support students outside of the classroom. **Quick Review** videos cover key definitions and procedures. **Example Solution** videos offer a detailed solution process for every example in the textbook.



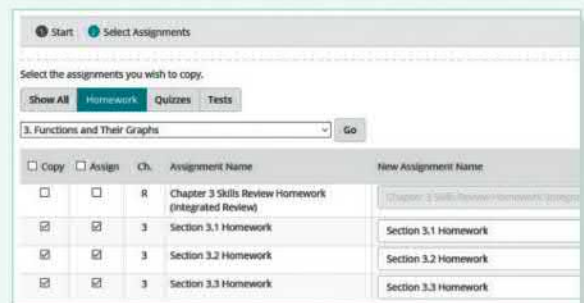
Updated! MyNotes and MyClassroomExamples

MyNotes give students a note-taking structure to use while they read the text or watch the MyLab Math videos. **MyClassroomExamples** offer structure for notes taken during lecture and are for use with the ClassroomExamples found in the Annotated Instructor Edition.

Both sets of notes are available in MyLab Math and can be customized by the instructor.

New! Enhanced Sample Assignments

Author Callie Daniels makes course set-up easier by giving instructors a starting point for each section. Following Callie's best practices in the classroom, Enhanced Sample Assignments maximize students' performance.



- **Section Prep Assignments** include Example Videos with assessment questions. This assignment pairs with **MyNotes**. Students actively participate while taking notes from the Example Video and then work the related exercises.
- **Section Homework** includes author-selected problems and increases in difficulty.
- **Cumulative Review Homework Assignments** draw from section homework questions covered to that point in the course—helping students prepare for a final exam.

Resources for Success



Instructor Resources

Online resources can be downloaded at pearson.com/mylab/math or from www.pearson.com.

Annotated Instructor's Edition

ISBN: 0135924499 / 9780135924495

Answers are included on the same page beside the text exercises where possible for quick reference. Helpful Teaching Tips and Classroom Examples are also provided.

Online Instructor's Solution Manual

By Beverly Fusfield

Provides complete solutions to all text exercises

Online Instructor's Testing Manual

Includes diagnostic pretests, grouped by section, with answers provided

Testgen[®]

TestGen (www.pearsoned.com/testgen) enables instructors to build, edit, print, and administer tests using a computerized bank of questions developed to cover all the objectives of the text.

PowerPoint[®] Lecture Slides and Classroom Example PowerPoints

- The PowerPoint Lecture Slides feature presentations written and designed specifically for this text, including figures and examples from the text.
- Classroom Example PowerPoints include fully worked-out solutions to all Classroom Examples.

Learning Catalytics[™]

With MyLab Math, instructors and students have access to Learning Catalytics, which instructors can use to generate class discussion, guide lectures, and actively engage students. Prebuilt Learning Catalytics questions have been created specifically for this text. Simply search the tag "LialPrecalculus" within the Learning Catalytics Question Library.

Student Resources

Additional resources enhance student success.

Student's Solution Manual

By Beverly Fusfield

Provides detailed solutions to all odd-numbered text exercises

Video Lectures

- Quick Reviews cover key definitions and procedures from each section.
- Example Solutions walk students through the detailed solution process for every example in the textbook.

MyNotes with Integrated Review Worksheets

MyNotes offer structure for students as they watch videos or read the text. These are available as a printed supplement and in MyLab Math.

- Includes textbook examples along with ample space for students to write solutions and notes
- Includes key concepts along with prompts for students to read, write, and reflect on what they have just learned
- **Customizable**—instructors can add their own examples or remove examples that are not covered in their course.

Integrated Review Worksheets prepare students for the College Algebra and Trigonometry material.

- Includes key terms, guided examples with ample space for students to work, and references to extra help in MyLab Math

MyClassroomExamples

- Available in MyLab Math and offer structure for classroom lecture
- Includes Classroom Examples along with ample space for students to write solutions and notes
- Includes key concepts along with fill-in-the-blank opportunities to keep students engaged
- **Customizable**—instructors can add their own examples or remove Classroom Examples that are not covered in their course.

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As an author team, we are committed to providing the best possible college algebra and trigonometry course to help instructors teach and students succeed. As we continue to work toward this goal, we welcome any comments or suggestions you might send, via e-mail, to math@pearson.com.

Margaret L. Lial
John Hornsby
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Callie J. Daniels

R

Review of Basic Concepts



Positive and negative numbers, used to represent gains and losses on a board such as this one, are examples of *real numbers* encountered in applications of mathematics.

- R.1 Fractions, Decimals, and Percents
- R.2 Sets and Real Numbers
- R.3 Real Number Operations and Properties
- R.4 Integer and Rational Exponents
- R.5 Polynomials
- R.6 Factoring Polynomials
- R.7 Rational Expressions
- R.8 Radical Expressions

R.1 Fractions, Decimals, and Percents

- **Lowest Terms of a Fraction**
- **Improper Fractions and Mixed Numbers**
- **Operations with Fractions**
- **Decimals as Fractions**
- **Operations with Decimals**
- **Fractions as Decimals**
- **Percents as Decimals and Decimals as Percents**
- **Percents as Fractions and Fractions as Percents**

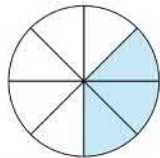
Recall that **fractions** are a way to represent parts of a whole. See **Figure 1**. In a fraction, the **numerator** gives the number of parts being represented. The **denominator** gives the total number of equal parts in the whole. The fraction bar represents division ($\frac{a}{b} = a \div b$).

$$\text{Fraction bar} \rightarrow \frac{3 \leftarrow \text{Numerator}}{8 \leftarrow \text{Denominator}}$$

A fraction is classified as either a **proper fraction** or an **improper fraction**.

Proper fractions	$\frac{1}{5}, \frac{2}{7}, \frac{9}{10}, \frac{23}{25}$	Numerator is less than denominator. Value is less than 1.
Improper fractions	$\frac{3}{2}, \frac{5}{5}, \frac{11}{7}, \frac{28}{4}$	Numerator is greater than or equal to denominator. Value is greater than or equal to 1.

Lowest Terms of a Fraction A fraction is in **lowest terms** when the numerator and denominator have no factors in common (other than 1).



The shaded region represents $\frac{3}{8}$ of the circle.

Figure 1

Writing a Fraction in Lowest Terms

- Step 1** Write the numerator and denominator in factored form.
- Step 2** Replace each pair of factors common to the numerator and denominator with 1.
- Step 3** Multiply the remaining factors in the numerator and in the denominator.

(This procedure is sometimes called “simplifying the fraction.”)

EXAMPLE 1 Writing Fractions in Lowest Terms

Write each fraction in lowest terms.

(a) $\frac{10}{15}$ (b) $\frac{15}{45}$ (c) $\frac{150}{200}$

SOLUTION

(a) $\frac{10}{15} = \frac{2 \cdot 5}{3 \cdot 5} = \frac{2}{3} \cdot \frac{5}{5} = \frac{2}{3} \cdot 1 = \frac{2}{3}$ 5 is the greatest common factor of 10 and 15.

(b) $\frac{15}{45} = \frac{1 \cdot 15}{3 \cdot 15} = \frac{1}{3} \cdot 1 = \frac{1}{3}$ Remember to write 1 in the numerator.

(c) $\frac{150}{200} = \frac{3 \cdot 50}{4 \cdot 50} = \frac{3}{4} \cdot 1 = \frac{3}{4}$ 50 is the greatest common factor of 150 and 200.

Another strategy is to choose *any* common factor and work in stages.

$$\frac{150}{200} = \frac{15 \cdot 10}{20 \cdot 10} = \frac{3 \cdot 5 \cdot 10}{4 \cdot 5 \cdot 10} = \frac{3}{4} \cdot 1 \cdot 1 = \frac{3}{4} \quad \text{The same answer results.}$$

Improper Fractions and Mixed Numbers A **mixed number** is a single number that represents the sum of a natural (counting) number and a proper fraction.

$$\text{Mixed number} \rightarrow 2\frac{3}{4} = 2 + \frac{3}{4}$$

EXAMPLE 2 Converting an Improper Fraction to a Mixed Number

Write $\frac{59}{8}$ as a mixed number.

SOLUTION Because the fraction bar represents division ($\frac{a}{b} = a \div b$, or $b \overline{)a}$), divide the numerator of the improper fraction by the denominator.

$$\begin{array}{r} \text{Denominator of fraction} \rightarrow 8 \overline{)59} \begin{array}{l} 7 \leftarrow \text{Quotient} \\ 56 \leftarrow \text{Numerator of fraction} \\ \underline{3} \leftarrow \text{Remainder} \end{array} \end{array} \quad \frac{59}{8} = 7\frac{3}{8}$$

✓ Now Try Exercise 17.

EXAMPLE 3 Converting a Mixed Number to an Improper Fraction

Write $6\frac{4}{7}$ as an improper fraction.

SOLUTION Multiply the denominator of the fraction by the natural number, and then add the numerator to obtain the numerator of the improper fraction.

$$7 \cdot 6 = 42 \quad \text{and} \quad 42 + 4 = 46$$

The denominator of the improper fraction is the same as the denominator in the mixed number, which is 7 here.

$$6\frac{4}{7} = \frac{7 \cdot 6 + 4}{7} = \frac{46}{7}$$

✓ Now Try Exercise 21.

Operations with Fractions

Figure 2 illustrates multiplying fractions.

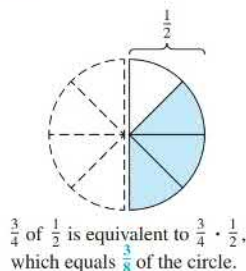


Figure 2

Multiplying Fractions

If $\frac{a}{b}$ and $\frac{c}{d}$ are fractions ($b \neq 0, d \neq 0$), then $\frac{a}{b} \cdot \frac{c}{d} = \frac{a \cdot c}{b \cdot d}$.

That is, to multiply two fractions, multiply their numerators and then multiply their denominators.

EXAMPLE 4 Multiplying Fractions

Multiply $\frac{3}{8} \cdot \frac{4}{9}$. Write the answer in lowest terms.

SOLUTION

$$\begin{aligned} & \frac{3}{8} \cdot \frac{4}{9} \\ &= \frac{3 \cdot 4}{8 \cdot 9} && \begin{array}{l} \text{Multiply numerators.} \\ \text{Multiply denominators.} \end{array} \\ &= \frac{12}{72} && \text{Multiply.} \\ &= \frac{1 \cdot 12}{6 \cdot 12} && \begin{array}{l} \text{The greatest common factor} \\ \text{of 12 and 72 is 12.} \end{array} \end{aligned}$$

Make sure the product is in lowest terms.

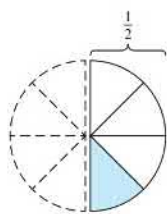
$$= \frac{1}{6} \quad \frac{1 \cdot 12}{6 \cdot 12} = \frac{1}{6} \cdot 1 = \frac{1}{6}$$

✓ Now Try Exercise 27.

Two numbers are **reciprocals** of each other if their product is 1. For example,

$$\frac{3}{4} \cdot \frac{4}{3} = \frac{12}{12}, \text{ or } 1.$$

Division is the inverse or opposite of multiplication, and as a result, we use reciprocals to divide fractions. **Figure 3** illustrates dividing fractions.



$\frac{1}{2} \div 4$ is equivalent to $\frac{1}{2} \cdot \frac{1}{4}$, which equals $\frac{1}{8}$ of the circle.

Figure 3

Dividing Fractions

If $\frac{a}{b}$ and $\frac{c}{d}$ are fractions ($b \neq 0, d \neq 0, c \neq 0$), then $\frac{a}{b} \div \frac{c}{d} = \frac{a}{b} \cdot \frac{d}{c}$.

That is, to divide by a fraction, multiply by its reciprocal.

EXAMPLE 5 Dividing Fractions

Divide. Write answers in lowest terms as needed.

(a) $\frac{3}{4} \div \frac{8}{5}$

(b) $\frac{5}{8} \div 10$

(c) $1\frac{2}{3} \div 4\frac{1}{2}$

SOLUTION

(a) $\frac{3}{4} \div \frac{8}{5}$

$$\begin{aligned} &= \frac{3}{4} \cdot \frac{5}{8} && \begin{array}{l} \text{Multiply by } \frac{5}{8}, \text{ the} \\ \text{reciprocal of } \frac{8}{5}. \end{array} \\ &= \frac{3 \cdot 5}{4 \cdot 8} && \begin{array}{l} \text{Multiply numerators.} \\ \text{Multiply denominators.} \end{array} \\ &= \frac{15}{32} && \text{Make sure the answer} \\ & && \text{is in lowest terms.} \end{aligned}$$

(b) $\frac{5}{8} \div 10$

$$\begin{aligned} &= \frac{5}{8} \cdot \frac{1}{10} && \begin{array}{l} \text{Think of 10 as } \frac{10}{1} \text{ here.} \\ \text{Multiply by } \frac{1}{10}, \\ \text{the reciprocal of 10.} \end{array} \\ &= \frac{5 \cdot 1}{8 \cdot 2 \cdot 5} && \text{Multiply and factor.} \\ &= \frac{1}{16} && \text{Remember to write 1} \\ & && \text{in the numerator.} \end{aligned}$$