

# Preface

Although *A Graphical Approach to Precalculus with Limits: A Unit Circle Approach* has evolved significantly from earlier editions, it retains the strengths of those editions and provides new and relevant opportunities for students and instructors alike. We realize that today's classroom experience is evolving and that technology-based teaching and learning aids have become essential to address the ever-changing needs of instructors and students. As a result, we have worked to provide support for all classroom types—traditional, hybrid, and online. In the seventh edition, text and online materials are more tightly integrated than ever before. This enhances flexibility and ease of use for instructors and increases success for students. See pages xviii–xx for descriptions of these materials.

This text incorporates an open design, helpful features, careful explanations of topics, and a comprehensive package of supplements and study aids. We continue to offer an *Annotated Instructor's Edition*, in which answers to both even- and odd-numbered exercises are provided either beside the exercises (if space permits) or in the back of the text for the instructor.

*A Graphical Approach to Precalculus with Limits: A Unit Circle Approach* was one of the first texts to reorganize the typical table of contents to maximize the use of graphs to support solutions of equations and inequalities. It maintains its unique table of contents and functions-based approach (as outlined in the Foreword and in front of the text) and includes additional components to build skills, address critical thinking, and give students a wealth of opportunities to solve applications and make use of technology to support traditional analytic solutions.

This text is part of a series that also includes the following titles:

- *A Graphical Approach to College Algebra, Seventh Edition*, by Hornsby, Lial, and Rockswold
- *A Graphical Approach to Algebra and Trigonometry, Seventh Edition*, by Hornsby, Lial, and Rockswold

The book is written to accommodate students who have access to graphing calculators. We have chosen to use screens from the TI-84 Plus C emulator. However, we do not include specific keystroke instructions because of the wide variety of models available. Students should refer to the guides provided with their calculators for specific information.

## New to This Edition

There are many places in the text where we have refined individual presentations and added examples, exercises, and applications based on reviewer feedback. The changes you may notice include the following:



- A **NEW** recurring feature is titled **Unifying Functions**. Following discussion of each of the important functions (for example, Unifying Linear Functions on page 67), we present a concise summary that covers Analyzing the Graph, Solving an Equation, Solving an Inequality, and Solving an Application. This feature reinforces the general approach of the text. Accompanying **videos** are embedded in the eText and **assessment questions** are available in MyLab Math.

- **Applications** have been updated throughout the text in such areas as organic food sales, video-on-demand, active Twitter users, worldwide WhatsApp usage, U.S. Snapchat users, top social networks, wearable technology, fast-food restaurant and advertising revenue, world records in track, college enrollment, poverty-level income cutoffs, health care expenditures, online sales, airport runway designations, online gaming revenue, population, vehicle sales, and pollutant emissions.
- Graphing calculator screens have been updated using the **TI-84 Plus C** emulator, often employing pedagogical color.
- **Chapter 1** New *Technology Note* explaining the equivalence of different function notation styles; updated examples throughout.
- **Chapter 2** More discussion about the constant function; more exercises that determine whether a function is odd or even; additional discussion, examples, and exercises about the order in which to apply combinations of transformations; the difference quotient and average rate of change; composite functions and their domains; additional examples of graphical solutions to equations and inequalities; a new subsection on error tolerances with examples and exercises; more graphing of absolute value functions by hand; a new example and exercises related to piecewise-defined functions.

*(Note: Chapter 3 from the previous edition has been divided into two chapters at the suggestion of reviewers. In the seventh edition, Chapter 3 consists of former Sections 3.1–3.4, and Chapter 4 consists of former Sections 3.5–3.8.)*

- **Chapter 3** Additional exercises on quotients of complex numbers; a new subsection on “A Quadratic Relation: The Circle” (this gives the instructor the option to cover circles and completing the square to find the center and radius earlier than in previous editions); new examples and exercises have been added throughout; exercises on complex numbers and exercises on circles have been added to the end-of-chapter Summary and Test.
- **Chapter 4** Introduces the terms *upper bound* and *lower bound*; updated examples and exercises appear throughout; additional exercises on polynomial function behavior.
- **Chapter 5** A new example about analyzing graphs of rational functions; new exercises where asymptotes are described using limit notation; new examples and exercises where rational functions are graphed by hand; new examples in which rational inequalities are solved; additional discussion about graphing circles with a calculator; new exercises that involve solving radical inequalities.
- **Chapter 6** Applications of logarithms with bases other than  $e$  and 10 have been supplemented with discussion of modern calculator capabilities of computing them directly (the change-of-base rule is still covered); a new example on modeling the number of monthly active Twitter accounts; new discussion, example, and exercises on modeling with logistic functions.
- **Chapter 7** Additional exercises that provide practice in solving systems of equations; more investment examples and applications; new coverage of systems that have infinitely many solutions; many new examples and exercises in which systems are solved by hand using row transformations; more discussion and exercises that involve solving rational inequalities; a new example and exercises about partial fraction decomposition.
- **Chapter 8** An example using parametric equations for an object in motion has been expanded; new exercises for parametric graphs have been included.

- **Chapter 9** A new subsection that discusses the real life application of airport runways, including an example and exercises; new examples of finding trigonometric function values using reference angles, finding angle measures by hand, evaluating trigonometric functions involving triangles, evaluating circular functions, and analyzing damped harmonic motion; new and additional exercises related to clock hands and angular velocity, rationalizing the denominator, reference angles, evaluating inverse trigonometric functions, solving triangles, finding exact values of trigonometric functions, writing equations of given graphs, modeling real data, damped harmonic motion, music, and function values as lengths of line segments.
- **Chapter 10** A complete revision of the material covering the inverse cotangent, inverse secant, and inverse cosecant functions, including new Function Capsules; new Concept Check exercises, including matching exercises; additional exercises related to solving trigonometric equations.
- **Chapter 11** New Concept Check exercises and a new Discussing Concept feature; rewording to make identities and trigonometry, in general, more accessible; additional graphing calculator explanations and solutions involving polar coordinates; new exercises involving whether a triangle with the given conditions exists; additional exercises involving plotting complex numbers in the complex plane.
- **Chapter 12** New exercises in solving inequalities that involve both sequences and series; new examples and exercises about mathematical induction; more discussion and exercises about odds in gambling.
- **Chapter 13** New examples covering limits at points of discontinuity, limits of square root functions, finding the equation of a tangent line and graphing it, interpreting the derivative in an application; new exercises involving limits at points of discontinuity, rational and trigonometric functions, both full and one-sided limits of square root, logarithmic, absolute value, and exponential functions; new exercises requiring equations of tangent lines, interpretation of the derivative, and evaluating a definite integral geometrically; two new Discussing Concepts.
- **Chapter R (formerly called “Reference,” now called “Review”)** A section on Review of Sets has been added.

## Features

We are pleased to offer the following enhanced features:

**Chapter Openers** Chapter openers provide a chapter outline and a brief discussion related to the chapter content.

**Enhanced Examples** We have replaced some examples and have included many new examples in this edition. We have also polished solutions and incorporated more explanatory comments and pointers.

**Hand-Drawn Graphs** We have incorporated many graphs featuring a “hand-drawn” style that simulates how a student might actually sketch a graph on grid paper. Accompanying videos are available in the MyLab Math multimedia library.

**Dual-Solution Format** Selected examples continue to provide side-by-side analytic and graphing calculator solutions, to connect traditional analytic methods for solving problems with graphical methods of solution or support. **NEW!** Embedded links in the eText enable students to launch a pop-up GeoGebra graphing calculator for these examples (see icon to left).



**Pointers** Comments with pointers (bubbles) provide students with on-the-spot explanations, reminders, and warnings about common pitfalls.

**Highlighted Section and Figure References** Within the text we use boldface type when referring to numbered sections and exercises (e.g., **Section 2.1, Exercises 15–20**). We also use a corresponding font when referring to numbered figures (e.g., **FIGURE 1**). We thank Gerald M. Kiser of Woodbury (New Jersey) High School for this latter suggestion.

**Figures and Photos** Today’s students are more visually oriented than ever. As a result, we have made a concerted effort to provide more figures, diagrams, tables, and graphs, including the “hand-drawn” style of graphs, whenever possible. And we often provide photos to accompany applications in examples and exercises.

**Function Capsules** These special boxes offer a comprehensive, visual introduction to each class of function and serve as an excellent resource for reference and review. Each capsule includes traditional and calculator graphs and a calculator table of values, as well as the domain, range, and other specific information about the function. Abbreviated versions of function capsules are provided on the inside back cover of the text.

**What Went Wrong?** This popular feature explores errors that students often make when using graphing technology and provides an avenue for instructors to highlight and discuss such errors. Answers are included on the same page as the “What Went Wrong?” boxes. Accompanying **videos** are available in the MyLab Math multimedia library.

**Cautions and Notes** These features warn students of common errors and emphasize important ideas throughout the exposition.

**Looking Ahead to Calculus** These margin notes provide glimpses into how the algebraic topics the students are currently studying are used in calculus.

**Algebra Reviews** This feature, which appears in the margin of the text, provides “just in time” review by indicating where students can find additional help with important topics from algebra.

**Technology Notes** Also appearing in the margin, these notes provide tips on how to use graphing calculators more effectively.

**Discussing Concepts** These activities appear within the exposition or in the margins and offer material on important concepts for instructors and students to investigate or discuss in class.

**Exercise Sets** We have taken special care to respond to the suggestions of users and reviewers and have added hundreds of new exercises to this edition on the basis of their feedback. The text continues to provide students with ample opportunities to practice, apply, connect, and extend concepts and skills. We have included writing exercises  as well as multiple-choice, matching, true/false, and completion problems. Exercises marked **CONCEPT CHECK** focus on mathematical thinking and conceptual understanding, while those marked **CHECKING ANALYTIC SKILLS** are intended to be solved *without the use of a calculator*.

**Relating Concepts** These groups of exercises appear in selected exercise sets. They link topics together and highlight relationships among various concepts and skills. All answers to these problems appear in the answer section at the back of the student text.

**Reviewing Basic Concepts** These sets of exercises appear every two or three sections and give students an opportunity to review and check their understanding of the material in preceding sections. All answers to these problems are included in the answer section.

**Chapter Review Material** One of the most popular features of the text, each end-of-chapter Summary features a section-by-section list of Key Terms and Symbols, in addition to Key Concepts. A comprehensive set of Chapter Review Exercises and a Chapter Test are also included.

## Acknowledgments

Previous editions of this text were published after thousands of hours of work, not only by the authors, but also by reviewers, instructors, students, answer checkers, and editors. To these individuals and to all those who have worked in some way on this text over the years, we are most grateful for your contributions. We could not have done it without you.

We especially wish to thank the following individuals who provided valuable input to this and previous editions of the text.

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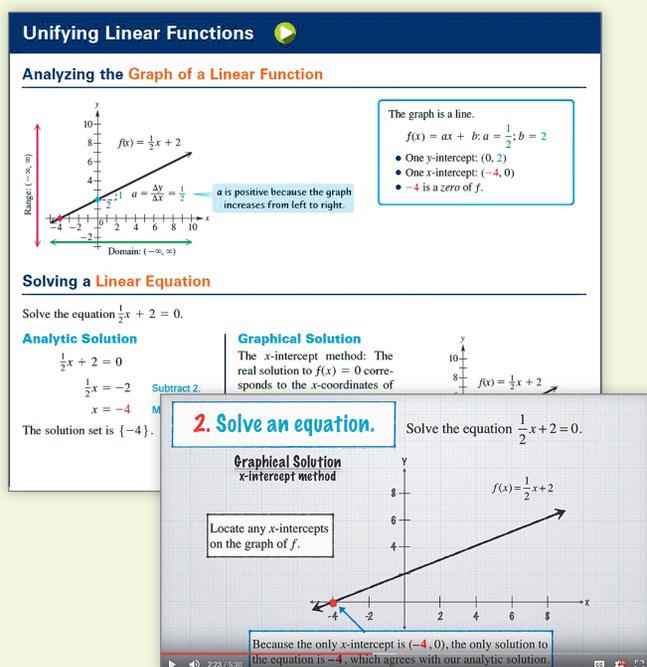
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*John Hornsby  
Gary Rockswold*

## MyLab™ Math Online Course for *A Graphical Approach to Precalculus with Limits: A Unit Circle Approach* 7th edition by Hornsby, Lial, and Rockswold (access code required)

MyLab Math is available to accompany Pearson's market-leading text offerings. To give students a consistent tone, voice, and teaching method, each text's flavor and approach is tightly integrated throughout the accompanying MyLab Math course, making learning the material as seamless as possible.

### Visualization and Conceptual Understanding



**Unifying Linear Functions**

**Analyzing the Graph of a Linear Function**

The graph is a line.  
 $f(x) = ax + b$ ;  $a = \frac{1}{2}$ ;  $b = 2$

- One y-intercept:  $(0, 2)$
- One x-intercept:  $(-4, 0)$
- $-4$  is a zero of  $f$ .

$a$  is positive because the graph increases from left to right.

**Solving a Linear Equation**

Solve the equation  $\frac{1}{2}x + 2 = 0$ .

**Analytic Solution**

$$\frac{1}{2}x + 2 = 0$$

$$\frac{1}{2}x = -2$$

Subtract 2

$$x = -4$$

The solution set is  $\{-4\}$ .

**Graphical Solution**

The x-intercept method: The real solution to  $f(x) = 0$  corresponds to the x-coordinates of

**2. Solve an equation.** Solve the equation  $\frac{1}{2}x + 2 = 0$ .

**Graphical Solution**  
x-intercept method

Locate any x-intercepts on the graph of  $f$ .

Because the only x-intercept is  $(-4, 0)$ , the only solution to the equation is  $-4$ , which agrees with our analytic solution.

### New! Unifying Functions

feature appears after the introduction of each of the major classes of functions. It provides a concise summary of the 4-step analytic process that drives this text: Analyze the Graph, Solve an Equation, Solve an Inequality, and Solve a Related Application.

New videos by contributor Jessica Rockswold accompany each instance of **Unifying Functions**; look for the hotspot in the eText. Assessment questions in MyLab Math allow instructors to assign these videos and test conceptual understanding.

### New! Example Solution Videos

engage and support students outside the classroom while covering key topics hand-picked by the authors. Lightboard technology creates a personal experience and simulates an in-class environment. Accompanying assessment questions in MyLab Math make these brand new videos assignable.



Solve  $\frac{x}{x-2} + \frac{1}{x+2} = \frac{6}{x^2-4}$ .

$$x-2 = 0$$

$$x = 2$$

$$x+2 = 0$$

$$x = -2$$

$$x^2 - 4 = 0$$

$$(x-2)(x+2) = 0$$

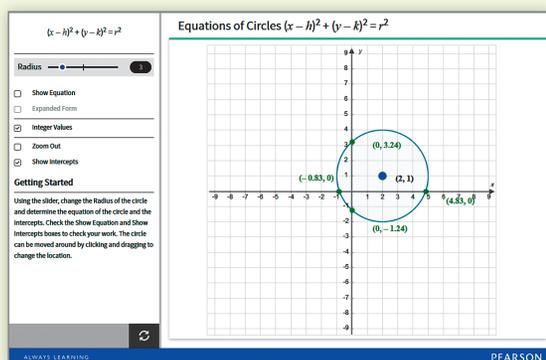
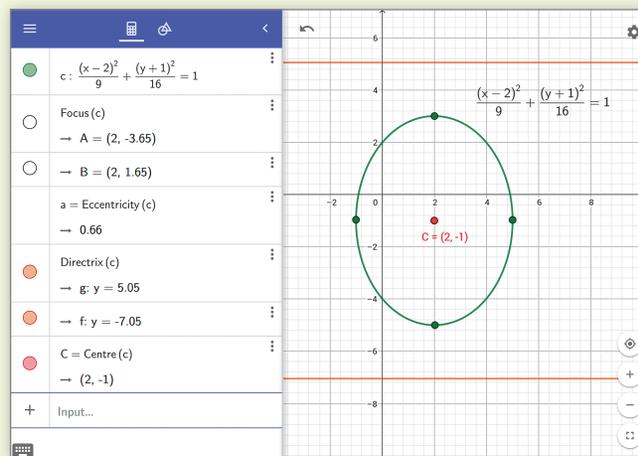
$$x-2 = 0 \text{ or } x+2 = 0$$

$$x = 2 \text{ or } x = -2$$



## New! GeoGebra® Graphing Calculator and Tutorials

support Hornsby's graphical approach. GeoGebra, an online graphing utility, is integrated into the MyLab Math course. Look for the GeoGebra icon within the eText to open a pop-up version, deploy in a new browser tab from Graphing Resources, or download the free app to use while doing homework. Interactive, self-checking tutorials make it easy to get started with this dynamic tool.



## Guided Visualizations

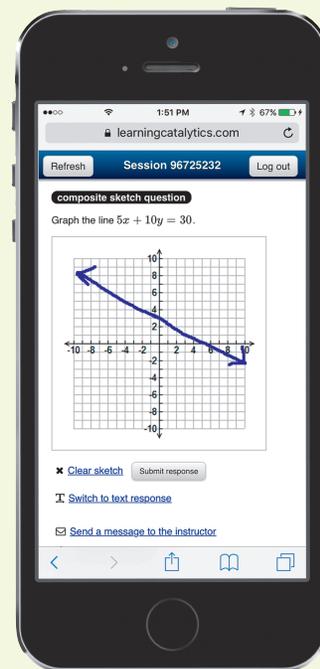
bring mathematical concepts to life, helping students visualize the concepts through directed explorations and purposeful manipulation. Guided Visualizations can be assigned in MyLab Math to encourage active learning, critical thinking, and conceptual understanding.

## Student Motivation

### Learning Catalytics

generate class discussion, guide your lecture, and promote peer-to-peer learning with real-time analytics. MyLab Math now provides Learning Catalytics—an interactive student response tool that uses students' smartphones, tablets, or laptops to engage them in more sophisticated tasks and thinking. Instructors, you can:

- Pose a variety of open-ended questions that help your students develop critical thinking skills.
- Monitor responses to find out where students are struggling.
- Use real-time data to adjust your instructional strategy and try other ways of engaging your students during class.
- Manage student interactions by automatically grouping students for discussion, teamwork, and peer-to-peer learning.





# Resources for Success

## Instructor Resources

These additional resources can be downloaded from [www.pearson.com](http://www.pearson.com) or from within your MyLab Math course.

### Annotated Instructor's Edition

This edition provides answers beside the text where possible for quick reference and in an answer section at the back of the book for all others.

### Instructor's Solutions Manual

By David Atwood, *Rochester Community and Technical College*

This manual provides complete solutions to all text exercises.

### TestGen®

TestGen ([www.pearsoned.com/testgen](http://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

The PowerPoint lecture slides feature presentations written and designed specifically for this text, including figures and examples from the text.

### Instructor's Testing Manual

By David Atwood, *Rochester Community and Technical College*

This testing manual contains four alternative tests for each chapter and corresponding answer keys.

### Student Activities Guides

By Susan Fife

This guide contains answers to *Precalculus Activities using WolframAlpha™* and *Engaging Algebra: Activities that Create Connections*.

### Sample Assignments in MyLab Math

Enhanced Sample Assignments, created by the authors, make course set-up easier by giving instructors a starting point for each chapter. Each assignment, handpicked by the author team to align

with this text, includes a thoughtful mix of question types (e.g., conceptual, skills, etc.) specific to that topic. Each assignment includes the newest MyLab Math question types including video assessments and guided visualizations.

### Learning Catalytics

Generate class discussion, guide your lecture, and promote peer-to-peer learning with real-time analytics. MyLab Math now provides Learning Catalytics—an interactive student response tool that uses students' smartphones, tablets, or laptops to engage them in more sophisticated tasks and thinking.

## Student Resources

These additional resources promote student success.

### Student's Solutions Manual

By David Atwood, *Rochester Community and Technical College*

This manual provides detailed solutions to odd-numbered Section and Chapter Review Exercises, as well as to all Relating Concepts, Reviewing Basic Concepts, and Chapter Test problems.

### Video Program

**Example Solution** videos provide comprehensive coverage of key topics in the text in an engaging format. **Unifying Functions** videos summarize the 4-step solving process featured throughout the textbook for each of the major classes of functions. All videos are assignable in MyLab Math and available in the Multimedia Library.

### Graphing Resources

Interactive tutorials and how-to videos are available for GeoGebra and TI-84 Plus, respectively. These resources and more can be found in the **Graphing Resources** tab in MyLab Math. Students will be able to launch the GeoGebra graphing calculator from that tab, within their eText, or by downloading the free app to use while completing assignments.