Prepare for Class: "Read the Book"

Feature	Description	Benefit	Page(s)
Every Chapter begins with . . .			
Chapter-Opening Topic & Project	Each chapter begins with a discussion of a topic of current interest and ends with a related project.	In the concluding project, you will apply what you have learned to solve a problem related to the topic.	424, 533
Internet-Based Projects	These projects allow for the integration of spreadsheet technology that you will need to be a productive member of the workforce.	The projects give you an opportunity to collaborate and use mathematics to deal with issues of current interest.	533
Every Section begins with . . .			
LEARNING OBJECTIVES 2	Each section begins with a list of objectives. Individual objectives also appear in the text where they are covered.	These objectives focus your studying by emphasizing what's most important and where to find it.	446
Sections contain . . .			
PREPARING FOR THIS SECTION	Most sections begin with a list of key concepts to review, with page numbers.	Ever forget what you've learned? This feature highlights previously learned material to be used in this section. Review it, and you'll always be prepared to move forward.	446
Now Work the 'Are You Prepared?' Problems	These problems assess whether you have the prerequisite knowledge for the upcoming section.	Work the 'Are You Prepared?' problems. If you get one wrong, you'll know exactly what you need to review and where to review it!	446, 458
Now Work PROBLEMS	These follow most examples and direct you to a related exercise.	We learn best by doing. You'll solidify your understanding of examples if you try a similar problem right away, to be sure you understand what you've just read.	454, 460
⚠ CAUTION	Words of caution are provided in the text.	These point out common mistakes and help you avoid them.	482
Explorations and Seeing the Concept	These graphing utility activities foreshadow a concept or reinforce a concept just presented.	You will obtain a deeper and more intuitive understanding of theorems and definitions.	441, 453
In Words	This feature provides alternative descriptions of select definitions and theorems.	Why didn't you say that in the first place? This feature translates math into plain English.	465
Calculus	This symbol appears next to information essential for the study of calculus.	Foreshadowing calculus now will make the material easier later.	220, 429, 454
SHOWCASE EXAMPLES	These examples provide "how to" instruction by offering a guided, step-by-step approach to solving a problem.	With each step presented on the left and the mathematics displayed on the right, you can immediately see how each step is employed.	358–359
Model It! Examples and Problems	These examples and problems require you to build a mathematical model from either a verbal description or data. The homework Model It! problems are marked by purple problem numbers.	It is rare for a problem to come in the form "*Solve the following equation.*" Rather, the equation must be developed based on an explanation of the problem. These problems require you to develop models that will enable you to describe the problem mathematically and suggest a solution to the problem.	472, 504
NEW! Need to Review?	These margin notes provide a just-in-time reminder of a concept needed now, but covered in an earlier section of the book. Each note is back-referenced to the chapter, section and page where the concept was originally discussed.	Sometimes as you read, you encounter a word or concept you know you've seen before, but don't remember exactly what it means. This feature will point you to where you first learned the word or concept. A quick review now will help you see the connection to what you are learning for the first time and make remembering easier the next time.	453

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Practice: "Work the Problems"

Feature	Description	Benefit	Page(s)
'Are You Prepared?' Problems	These problems assess your retention of the prerequisite material. Answers are given at the end of the section exercises. This feature is related to the Preparing for This Section feature.	Do you always remember what you've learned? Working these problems is the best way to find out. If you get one wrong, you'll know exactly what you need to review and where to review it!	446, 458
Concepts and Vocabulary	These short-answer questions, mainly fill-in-the-blank, multiple-choice, and true/false items, assess your understanding of key definitions and concepts in the current section.	It is difficult to learn math without knowing the language of mathematics. These problems test your understanding of the formulas and vocabulary.	458–459
Skill Building	Correlated with section examples, these problems provide straightforward practice.	These problems give you ample opportunity to dig in and develop your skills.	459–461
Mixed Practice	These problems offer comprehensive assessment of the skills learned in the section by asking problems related to more than one concept or objective. These problems may also require you to utilize skills learned in previous sections.	Learning mathematics is a building process. Many concepts build on each other and are related. These problems help you see how mathematics builds on itself and how the concepts are linked together.	461
Applications and Extensions	These problems allow you to apply your skills to real-world problems. They also enable you to extend concepts learned in the section.	You will see that the material learned within the section has many uses in everyday life.	461–464
NEW! Challenge Problems	These problems have been added in most sections and appear at the end of the Application and Extensions exercises. They are intended to be thought-provoking, requiring some ingenuity to solve.	Challenge problems can be used for group work or to challenge your students. Solutions to Challenge Problems are in the Annotated Instructor's Edition or in the Instructor's Solution Manual (online).	464
Explaining Concepts: Discussion and Writing	"Discussion and Writing" problem numbers are colored red. They support class discussion, verbalization of mathematical ideas, and writing and research projects.	To verbalize an idea, or to describe it clearly in writing, shows real understanding. These problems nurture that understanding. Many are challenging, but you'll get out what you put in.	464
Retain Your Knowledge	These problems allow you to practice content learned earlier in the course.	Remembering how to solve all the different kinds of problems that you encounter throughout the course is difficult. This practice helps you remember previously learned skills.	464
Now Work PROBLEMS	Many examples refer you to a related homework problem. These related problems are marked by and orange problem numbers.	If you get stuck while working problems, look for the closest Now Work problem, and refer to the related example to see if it helps.	454, 456, 457
NEW! Interactive Figure Exercises	Exercises that require you manipulate an interactive figure to solve. These exercises are labeled with the icon .	These exercises help you visualize important concepts and develop a "feel" for them. The figures are housed at `bit.ly/2Mibga0` and were developed in GeoGebra by author Michael Sullivan III.	458, 459, 473, 474
Review Exercises	Every chapter concludes with a comprehensive list of exercises to practice. Use the list of objectives to determine what objective and examples correspond to each problem.	Work these problems to ensure that you understand all the skills and concepts employed in the chapter. Think of it as a comprehensive review of the chapter. All answers to Chapter Review problems appear in the back of the text.	528–531

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Review: "Study for Quizzes and Tests"

Feature	Description	Benefit	Page(s)
Most Sections Contain			
Retain Your Knowledge	Keeps what you have learned at the forefront and see how topics are connected.	These problems allow content to remain fresh so you are more prepared for the final exam.	478
The Chapter Review at the end of each chapter contains . . .			
Things to Know	A detailed list of important theorems, formulas, and definitions from the chapter.	Review these and you'll know the most important material in the chapter!	526–527
You Should Be Able to . . .	A complete list of objectives by section, examples that illustrate the objective, and practice exercises that test your understanding of the objective.	Do the recommended exercises and you'll have mastered the key material. If you get something wrong, go back and review the example listed, and try again.	527–528
Review Exercises	These provide comprehensive review and practice of key skills, matched to the Learning Objectives for each section.	Practice makes perfect. These problems combine exercises from all sections, giving you a comprehensive review in one place.	528–531
Chapter Test	About 15–20 problems that can be taken as a Chapter Test. Be sure to take the Chapter Test under test conditions—no notes!	Be prepared. Take the sample practice test under test conditions. This will get you ready for your instructor's test. If you get a problem wrong, you can watch the Chapter Test Prep Video.	531–532
Cumulative Review	These problem sets appear at the end of each chapter, beginning with Chapter 2. They combine problems from previous chapters, providing an ongoing cumulative review. When you use them in conjunction with the Retain Your Knowledge problems, you will be ready for the final exam.	These problem sets are really important. Completing them will ensure that you are not forgetting anything as you go. This will go a long way toward keeping you primed for the final exam.	532–533

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ANNOTATED INSTRUCTOR'S EDITION

College Algebra

Enhanced with Graphing Utilities

Eighth Edition

Michael Sullivan
Chicago State University

Michael Sullivan III
Joliet Junior College

Pearson

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In Memory of Mary . . .
Wife and Mother

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Three Distinct Series to Meet Varied Instructional Needs

Students have different goals, learning styles, and levels of preparation. Instructors have different teaching philosophies, styles, and techniques. Rather than write one series to fit all, the Sullivans have written three distinct series. All share the same goal—to develop a high level of mathematical understanding and an appreciation for the way mathematics can describe the world around us. The manner of reaching that goal, however, differs from series to series.

Enhanced with Graphing Utilities Series

This series provides a thorough integration of graphing utilities into topics, allowing students to explore mathematical concepts and encounter ideas usually studied in later courses. Many examples show solutions using algebra side-by-side with graphing techniques. Using technology, the approach to solving certain problems differs from the Contemporary (Flagship) or Concepts through Functions Series, while the emphasis on understanding concepts and building strong skills is maintained. Texts in this series are *College Algebra, Algebra & Trigonometry,* and *Precalculus.*

Flagship Series

The Flagship Series is the most traditional in approach, yet modern in its treatment of precalculus mathematics. In each text, needed review material is included and is referenced when it is used. Graphing utility coverage is optional and can be included or excluded at the discretion of the instructor. Texts in this series are *College Algebra, Algebra & Trigonometry, Trigonometry: A Unit Circle Approach, and Precalculus.*

Concepts through Functions Series

This series differs from the others, utilizing a functions approach that serves as the organizing principle tying concepts together. Functions are introduced early in various formats. This approach supports the Rule of Four, which states that functions are represented symbolically, numerically, graphically, and verbally. Each chapter introduces a new type of function and then develops all concepts pertaining to that particular function. The solutions of equations and inequalities, instead of being developed as stand-alone topics, are developed in the context of the underlying functions. Graphing utility coverage is optional and can be included or excluded at the discretion of the instructor. Texts in this series are *College Algebra; Precalculus, with a Unit Circle Approach to Trigonometry; Precalculus, with a Right Triangle Approach to Trigonometry.*

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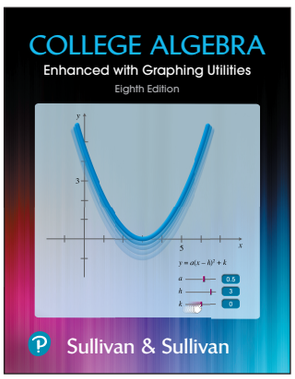
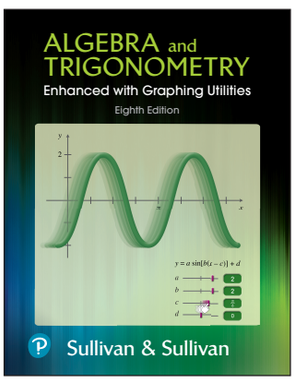
The Enhanced with Graphing Utilities Series

College Algebra, Eighth Edition



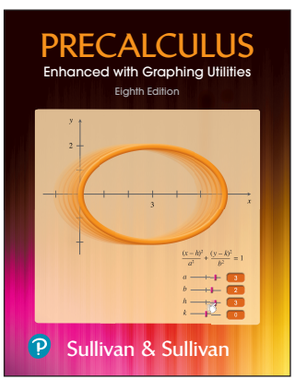
This text provides an approach to college algebra that completely integrates graphing technology without sacrificing mathematical analysis and conceptualization. The text has three chapters of review material preceding the chapter on functions. Graphing calculator usage is integrated throughout. After completing this text, a student will be prepared for trigonometry, finite mathematics, and business calculus.

Algebra & Trigonometry, Eighth Edition



This text contains all the material in *College Algebra,* but it also develops the trigonometric functions using a right triangle approach and shows how that approach is related to the unit circle approach. Graphing techniques are emphasized, including a thorough discussion of polar coordinates, parametric equations, and conics using polar coordinates. Vectors in the plane, including the dot product, sequences, induction, and the binomial theorem are also presented. After completing this text, a student will be prepared for finite mathematics, business calculus, and engineering calculus.

Precalculus, Eighth Edition



This text contains a review chapter before covering the traditional precalculus topics of functions and their graphs, polynomial and rational functions, and exponential and logarithmic functions. The trigonometric functions are introduced using a unit circle approach and show how it is related to the right triangle approach. Graphing techniques are emphasized, including a thorough discussion of polar coordinates, parametric equations, and conics using polar coordinates. Vectors in the plane and in space, including the dot and cross products, sequences, induction, and the binomial theorem are also presented. Graphing calculator usage is integrated throughout. The final chapter provides an introduction to calculus, with a discussion of the limit, the derivative, and the integral of a function. After completing this text, a student will be prepared for finite mathematics, business calculus, and engineering calculus.

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Preface to the Instructor

As professors at an urban university (Michael Sullivan) and a community college (Michael Sullivan III), we are aware of the varied needs of students in this course. Such students range from those who have little mathematical background and are fearful of mathematics courses to those with a strong mathematical education and a high level of motivation. For some of your students, this will be their last course in mathematics, whereas others will further their mathematical education. We have written this text with both groups in mind.

As a teacher, and as an author of precalculus, engineering calculus, finite mathematics, and business calculus texts, Michael Sullivan understands what students must know if they are to be focused and successful in upper-level math courses. As an instructor and an author of a developmental mathematics series, Michael's son and co-author, Michael Sullivan III, understands the trepidations and skills that students bring to the College Algebra course. As the father of current college students, Michael III realizes that today's college students demand a variety of media to support their education. This text addresses that demand by providing technology and video support that enhances understanding without sacrificing math skills. Together, we have taken great pains to ensure that the text offers solid, student-friendly examples and problems, as well as a clear and seamless writing style.

A tremendous benefit of authoring a successful series is the broad-based feedback we receive from teachers and students. We are sincerely grateful for their support. Virtually every change in this edition is the result of their thoughtful comments and suggestions. We are confident that, building on the success of the first seven editions and incorporating many of these suggestions, we have made *College Algebra Enhanced with Graphing Utilities,* 8th Edition, an even better tool for learning and teaching. We continue to encourage you to share with us your experiences teaching from this text.

Features in the Eighth Edition

A descriptive list of the many special features of *College Algebra* can be found in the front of this text. This list places the features in their proper context as building blocks of an overall learning system that has been carefully crafted over the years to help students get the most out of the time they put into studying. Please take the time to review this and to discuss it with your students at the beginning of your course. Our experience is that when students utilize these features, they are more successful in the course.

New to the Eighth Edition

New Within the Textbook

All of the exercises and examples in the text have been reviewed and analyzed, and we have incorporated feedback from users of the text. All time-sensitive problems have been updated to the most recent information available. Here are the new features of this edition:

- **Challenge Problems** – These problems appear in the Applications and Extensions part of the section exercises and are designed to challenge students. Full solutions are in the back of the Annotated Instructor's Edition and in the Instructor's Solution Manual.
- **"Need to Review?" feature** – We placed reminders in the margin for key review topics. The reminders point students to the location of the review material in the textbook.
- **Chapter Projects** – The projects have been enhanced to give students an up-to-the-minute experience. Many of these projects require the student to research information online in order to solve problems.
- **Interactive Figure Exercises** – We have added this new category of exercises that require students to manipulate an interactive figure to solve. The interactive figures may be found at `bit.ly/2MibgaO` or in the Video and Resource Library of MyLab Math, and were created by author Michael Sullivan III in GeoGebra. These exercises are labeled with the icon .
- **Expanded! Retain Your Knowledge Problems** – These problems, which were new to the previous edition, are based on learning research, including a study of precalculus students at University of Louisville entitled "Spaced retrieval practice increases college students' short- and long-term retention of mathematics knowledge" (Hopkins et al, 2016). The Retain Your Knowledge problems were so well received that we have expanded them in this edition. Moreover, while the focus remains to help students maintain their skills, in most sections, problems were chosen that preview skills required to succeed in subsequent sections or in calculus ( ). All answers to Retain Your Knowledge problems are given in the back of the text and these problems are available in the prebuilt assignments in the Assignment Manager in MyLab Math.
- **Key to Exercise Types** – To help you navigate the features of the exercise sets, we've included a key at the bottom of the first page of each section's exercises.

Now Work 1. Modeling 1. Writing/Discussion
Calculus Preview Interactive Figure

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- **Graphing Utility Screen Captures** – In several instances we have added Desmos screen captures along with the TI-84 Plus CE screen captures. These updated screen captures provide alternative ways of visualizing concepts and making connections between equations, data, and graphs in full color.

Content Changes

Chapter R

- Section R.8 Objective 3 now includes rationalizing the numerator. Problems 69–76 provide practice.

Chapter 1

- Section 1.1 has been reorganized to only include an introduction to graphing and graphing utilities.

Chapter 2

- NEW Section 2.1 The Distance and Midpoint Formulas
- NEW Section 2.2 Example 5 Testing an Equation for Symmetry

Chapter 3

- NEW Section 3.1 Objective 1 Describe a Relation
  - NEW Example 1 Describing a Relation demonstrates using the Rule of Four to express a relation numerically, as a mapping, and graphically given a verbal description.
- NEW Section 3.2 Example 4 Expending Energy

Chapter 4

- Section 4.3 now introduces the concept of concavity for a quadratic function.
- NEW Section 4.3 Example 3 Graphing a Quadratic Function Using Its Vertex, Axis, and Intercepts
- Section 4.3 Example 8 Analyzing the Motion of a Projectile (formerly in Section 4.4)
- NEW Section 4.4 Example 4 Fitting a Quadratic Function to Data

Chapter 5

- Previous Section 5.1 has been revised and split into two sections:
  - 5.1 Polynomial Functions
  - 5.2 Graphing Polynomial Functions; Models
- NEW Section 5.2 Example 2 Graphing a Polynomial Function (a 4th degree polynomial function)

Chapter 6

- NEW Section 6.2 Objective Verify a Function Defined by an Equation is an Inverse Function

Chapter 8

- NEW Section 8.5 Example 1 Identifying Proper and Improper Rational Expressions

Chapter 9

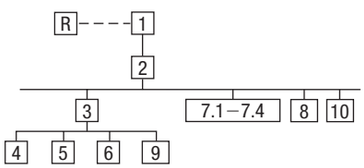
- NEW Section 9.3 Objective 5 Solving Annuity Problems Using Formulas

New Within MyLab Math

- **Setup & Solve Exercises** require students to show how they set up a problem as well as the solution, better mirroring what is required of them on tests. We have included both the "traditional" and Setup & Solve versions of exercise within MyLab to provide you with more options for assessing students.
- **Integrated Review** content and assessments help you provide students with the remediation they need, when they need it. Integrated Review consists of:
  - **Skills Check Quizzes** by chapter assess the prerequisite skills students need for that chapter.
  - **Skills Review Homework**, again by chapter, is personalized (based on the results of the Skills Check Quiz) to provide students with help on the prerequisite skills they are lacking. Students receive just the help they need—no more, no less.
  - **Intermediate Algebra eText, Exercises, Videos, and Worksheets**—For students who need more help (or for co-requisite courses), we've included the contents of a streamlined Intermediate Algebra course within this MyLab course. There's no need to go elsewhere for remediation.
- **Interactive Figures** (formerly titled Guided Visualizations) have been expanded to support teaching and learning. The figures (created in GeoGebra by author Michael Sullivan III) illustrate key concepts and allow manipulation. They have been designed to be used in lecture as well as by students independently.
- **Enhanced Sample Assignments** are pre-made section-level assignments that address key concepts within the section and help keep previously learned skills fresh with Retain Your Knowledge questions. They are assignable and editable.

Using the Eighth Edition Effectively with Your Syllabus

To meet the varied needs of diverse syllabi, this text contains more content than is likely to be covered in a College Algebra course. As the chart illustrates, this text has been organized with flexibility of use in mind. Within a given chapter, certain sections are optional (see the details that follow the accompanying figure) and can be omitted without loss of continuity.



Chapter R Review

This chapter consists of review material. It may be used as the first part of the course or later as a just-in-time review when the content is required. Specific references to this chapter occur throughout the text to assist in the review process.

Chapter 1 Equations and Inequalities
Primarily a review of intermediate algebra topics, this material is a prerequisite for later topics. The coverage of complex numbers and quadratic equations with a negative discriminant is optional and may be postponed or skipped entirely without loss of continuity.

Chapter 2 Graphs
This chapter lays the foundation for functions. Section 2.5 is optional.

Chapter 3 Functions and Their Graphs
This is perhaps the most important chapter. Section 3.6 is optional.

Chapter 4 Linear and Quadratic Functions
Topic selection depends on your syllabus. Sections 4.2 and 4.4 may be omitted without loss of continuity.

Chapter 5 Polynomial and Rational Functions
Topic selection depends on your syllabus.

Chapter 6 Exponential and Logarithmic Functions
Sections 6.1–6.6 follow in sequence. Sections 6.7, 6.8, and 6.9 are optional.

Chapter 7 Analytic Geometry
Sections 7.1–7.4 follow in sequence.

Chapter 8 Systems of Equations and Inequalities
Sections 8.2–8.7 may be covered in any order, but each requires Section 8.1. Section 8.8 requires Section 8.7.

Chapter 9 Sequences; Induction; The Binomial Theorem
There are three independent parts: Sections 9.1–9.3, Section 9.4, and Section 9.5.

Chapter 10 Counting and Probability
The sections follow in sequence.

Acknowledgments
Texts are written by authors, but they evolve from idea to final form through the efforts of many people.

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- Accuracy checkers: Roger Lipsett read the entire manuscript and checked the accuracy of answers. Timothy Britt created the Solutions Manuals and accuracy-checked answers.
- Michael Sullivan III would like to thank his colleagues at Joliet Junior College for their support and feedback.

Finally, we offer our sincere thanks to the dedicated users and reviewers of our texts, whose collective insights form the backbone of each text revision.

The list of those to whom we are indebted continues to grow. If we've forgotten anyone, please accept our apology. Thank you to all.

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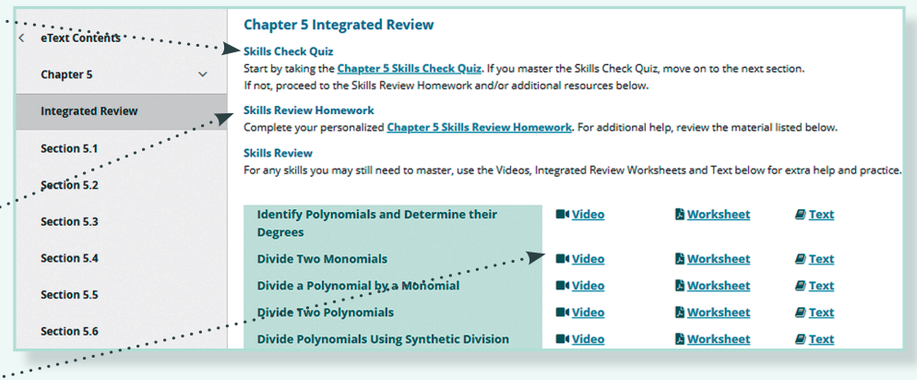
Integrated Review in MyLab Math

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.

- 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 videos featuring Michael Sullivan III, worksheets, and Sullivan's *Algebra Review* text, are available.



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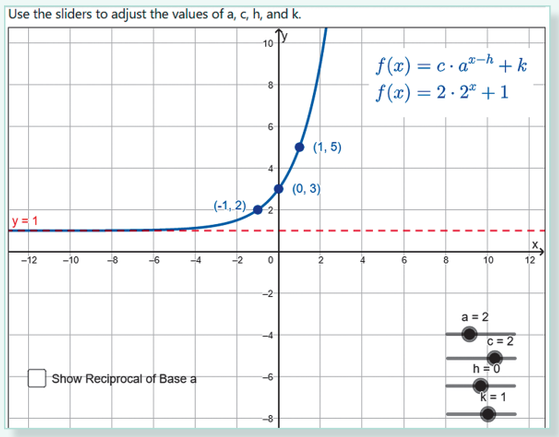
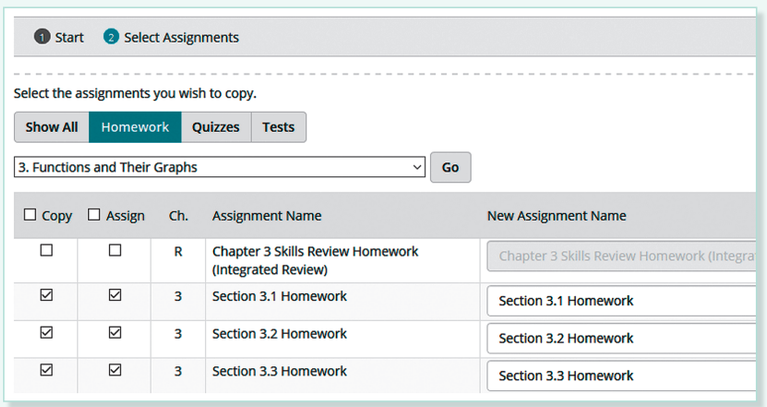
New! Interactive Figures

Interactive Figures, created in GeoGebra by Michael Sullivan III, bring mathematical concepts to life, helping students visualize the concept through guided exploration and purposeful manipulation. Assignable in MyLab Math with assessment questions to check students' conceptual understanding.





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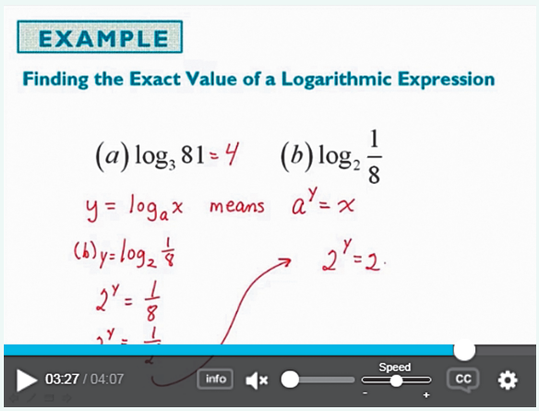

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To the Student

As you begin, you may feel anxious about the number of theorems, definitions, procedures, and equations you encounter. You may wonder if you can learn it all in time. Don't worry, your concerns are normal. This text was written with you in mind. If you attend class, work hard, and read and study effectively, you will build the knowledge and skills you need to be successful. Here's how you can use the text to your benefit.

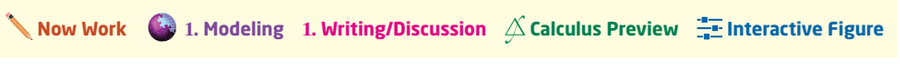
Read Carefully

When you get busy, it's easy to skip reading and go right to the problems. Don't! The text provides a large number of examples and clear explanations to help you break down the mathematics into easy-to-understand steps. Reading will provide you with a clearer understanding, beyond simple memorization. Read before class (not after) so you can ask questions about anything you didn't understand. You'll be amazed at how much more you'll get out of class when you do this.

Use the Features

We use many different methods in the classroom to communicate. Those methods, when incorporated into the text, are called "features." The features serve many purposes, from supplying a timely review of material you learned before (just when you need it), to providing organized review sessions to help you prepare for quizzes and tests. Take advantage of the features and you will master the material.

To make this easier, we've provided a brief guide to getting the most from this book. Refer to the "Prepare for Class," "Practice," and "Review" guidelines on the first three pages of this book. Spend fifteen minutes reviewing the guide and familiarizing yourself with the features by flipping to the page numbers provided. Then, as you read, use them. This is the best way to make the most of your text. In this edition, we've also added a handy key to the labeling of the homework exercises so that you know what the colors and icons mean:



Please do not hesitate to contact us via Math@Pearson.com with any questions, comments, or suggestions about ways to improve this text. We look forward to hearing from you, and good luck with all of your studies.

Best Wishes!

Michael Sullivan
Michael Sullivan III

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