

GLOBAL
EDITION



Calculus with Applications

ELEVENTH EDITION

Margaret L. Lial • Raymond N. Greenwell • Nathan P. Ritchey

 Pearson

Calculus with Applications

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Preface

Calculus with Applications is a thorough, applications-oriented text for students majoring in business, management, economics, or the life or social sciences. In addition to its clear exposition, this text consistently connects the mathematics to career and everyday-life situations. A prerequisite of two years of high school algebra is assumed. A greatly enhanced MyMathLab course, new applications and exercises, and other new learning tools make this 11th edition a rich learning resource for students.

Our Approach

Our main goal is to present applied calculus in a concise and meaningful way so that students can understand the full picture of the concepts they are learning and apply them to real-life situations. This is done through a variety of means.

Focus on Applications Making this course meaningful to students is critical to their success. Applications of the mathematics are integrated throughout the text in the exposition, the examples, the exercise sets, and the supplementary resources. We are constantly on the lookout for novel applications, and the text reflects our efforts to infuse it with relevance. Our research is showcased in the Index of Applications at the back of the book and the extended list of sources of real-world data on www.pearsonglobaleditions.com/lial. *Calculus with Applications* presents students with myriad opportunities to relate what they're learning to career situations through the *Apply It* question at the beginning of sections, the applied examples and exercises, and the *Extended Application* at the end of each chapter.

Pedagogy to Support Students Students need careful explanations of the mathematics along with examples presented in a clear and consistent manner. Additionally, students and instructors should have a means to assess the basic prerequisite skills needed for the course content. This can be done with the *Prerequisite Skills Diagnostic Test*, located just prior to Chapter R. If the diagnostic test reveals gaps in basic skills, students can find help right within the text. Further, *Warm-Up Exercises* are now included at the beginning of many exercise sets. Within MyMathLab are additional diagnostic tests (one per chapter), and remediation is automatically personalized to meet student needs. Students will appreciate the many annotated examples within the text, the *Your Turn* exercises that follow examples, the *For Review* references, and the wealth of learning resources within MyMathLab.

Beyond the Textbook Students want resources at their fingertips and, for them, that means digital access. So Pearson has developed a robust MyMathLab course for *Calculus with Applications*. MyMathLab has a well-established and well-documented track record of helping students succeed in mathematics. The MyMathLab online course for this text contains over 2100 exercises to challenge students and provides help when they need it. Students who learn best through video can view (and review) section- and example-level videos within MyMathLab. These and other resources are available to students as a unified and reliable tool for their success.

New to the Eleventh Edition

Based on our experience in the classroom along with feedback from many instructors across the country, the focus of this revision is to improve the clarity of the presentation and provide students with more opportunities to learn, practice, and apply what they've learned on their own. We do this both in the presentation of the content and in the new features added to the text.

New Features

- *Warm-Up Exercises* were added to many exercise sets to provide an opportunity for students to refresh key prerequisite skills at “point of use.”
- Graphing calculator screens have been updated to reflect the TI-84 Plus C, which features color and a higher screen resolution. Additionally, the graphing calculator notes have been updated throughout.
- We added more “help text” annotations to examples. These notes, set in small blue type, appear next to the steps within worked-out examples and provide an additional aid for students with weaker algebra skills.
- For many years this text has featured enormous amounts of real data used in examples and exercises. The 11th edition will not disappoint in this area. We have added or updated 157 (15.9%) of the application exercises throughout the text.
- We updated exercises and examples based on user feedback and other factors. Of the 3516 exercises within the sections, 397 (11.2%) are new or updated. Of the 413 examples in the text, 55 (13.3%) are new or updated.
- MyMathLab contains a wealth of new resources to help students learn and to help you as you teach. Some resources were added or revised based on student usage of the *previous* edition of the MyMathLab course. For example, more exercises were added to those chapters and sections that are more widely assigned.
 - Hundreds of new exercises were added to the course to provide you with more options for assignments, including:
 - More application exercises throughout the text
 - *Setup & Solve* exercises that require students to specify how to set up a problem as well as solve it
 - Exercises that take advantage of the enhanced graphing tool
 - The videos for the course have increased in number, type, and quality:
 - New videos feature more applications and more challenging examples.
 - In addition to full-length lecture videos, MyMathLab now includes assignable, shorter video clips that focus on a specific concept or example.
 - MathTalk Videos help motivate students by pointing out relevant connections to their majors—especially business. The videos feature Andrea Young from Ripon College (WI), a dynamic math professor (and actor!). The videos can be used as lecture starters or as part of homework assignments (in regular or flipped classes). Assignable exercises that accompany the videos help make these videos a part of homework assignments.
 - A Guide to Video-Based Instruction shows which exercises correspond to each video, making it easy to assess students after they watch an instructional video. This is perfect for flipped-classroom situations.
 - Learning Catalytics is a “bring your own device” student engagement, assessment, and classroom intelligence system. Students can use any web-enabled device—laptop, smartphone, or tablet—that they already have. Those with access to MyMathLab have instant access to Learning Catalytics and can log in using their MyMathLab username and password. With Learning Catalytics, you assess students in real time, using open-ended tasks to probe student understanding. It allows you to engage students by creating open-ended questions that ask for numerical, algebraic, textual, or graphical responses—or just simple multiple-choice. Learning Catalytics contains Pearson-created content for calculus so you can take advantage of this exciting technology immediately.

New and Revised Content

The chapters and sections in the text are in the same order as the previous edition, making it easy for users to transition to the new edition. In addition to revising exercises and examples throughout, updating and adding real-world data, we made the following changes:

Chapter R

- Added new *Your Turn* exercises to ensure that there is a student assessment for each major concept.
- Added more detail to R.2 on factoring perfect squares.

Chapter 1

- Rewrote the part of 1.1 involving graphing lines, emphasizing different methods for graphing.
- Rewrote 1.2 on supply, demand, break-even analysis, and equilibrium; giving formal definitions that match what students would see in business and economics courses. All of the business applications were revised, according to recommendations from reviewers, to be more in line with business texts. Also added a new Example 6 on finding a cost function.
- Added color for pedagogical reasons to make content easier to follow.

Chapter 2

- Updated the introduction to 2.1, rewriting it as an example to make it easier for students to reference the necessary skills to identify nonlinear functions, determine the domain and range, and estimate values from a graph.
- In 2.2, added another approach to graphing parabolas by splitting former Example 4 into two separate examples. The new Example 5 illustrates how to graph a parabola by first finding its characteristics (including orientation, intercepts, vertex, and axis of symmetry). The characteristics are highlighted in a box for easy reference.
- Added quadratic regression to 2.2. Example 9 includes a by-hand method and a method using technology.
- Rewrote Example 10 in 2.2, which illustrates translations and reflections of a graph, by breaking it into three parts. The first part is a basic transformation, and the ensuing parts build in complexity.
- Added the definition of a real root to 2.3 and added a Technology Note to illustrate how to use a graphing calculator to approximate the roots of higher degree polynomials.
- Added cubic regression to 2.3 (Example 5).

Chapter 3

- Added Caution note to 3.1 and added a new solution method to Example 9.
- Added new Example 2 to 3.3, using recent data.
- Updated Example 4 in 3.3 to use clearer wording.

Chapter 4

- Clarified the rules for differentiation in 4.1, 4.2, and 4.3 and added a new Example 8.
- Expanded Example 9 in 4.1 to include a new graph.
- Updated Example 10 in 4.1 and Example 4 in 4.5.

Chapter 5

- Added new examples to 5.2 (Example 3(c)) and 5.3 (Example 6(b)).
- Expanded Example 6(a) in 5.4 to show the inflection point.

Chapter 6

- Updated Example 3 in 6.1 to show an application of the concept.
- Modified examples in 6.2 (Example 3), 6.4 (Example 2), and 6.6 (Example 1).

Chapter 7

- Added annotations and comments to Example 10 in 7.1.
- Simplified Examples 1, 2, 3, and 6 in 7.2 and added annotations and comments.
- Added a “For Review” box to 7.3.
- Enlarged all small integral signs throughout the chapter for clarity.
- Updated Example 7 in 7.4 and Example 5 in 7.5.
- Added more explanation of the consumer surplus to 7.5.

Chapter 8

- Added annotations to several examples in 8.1 to denote steps in integration by parts.
- Revised the solutions to Examples 4 and 5 in 8.3, giving more detail and adding annotation to denote the steps in determining the accumulated amount of money flow.

Chapter 9

- Rewrote and expanded Exercise 8 in 9.1, on the Cobb-Douglas Production Function, emphasizing the interpretation of the solutions.
- Added three new exercises to 9.1 on exponential and logarithmic functions of several variables.
- Revised the solution to Example 4 in 9.3, giving more detail.
- Rewrote the solution to Example 3 in 9.4, illustrating how to find the extrema of a constrained function of one or more variables using a spreadsheet.

Chapter 10

- Revised the solution to Example 5 in 10.1, adding annotation to denote steps in separation of variables.
- In 10.1, added the definition of equilibrium point, explained how to determine the stability (stable, unstable, or semistable) of the equilibrium point, and added Example 8 on equilibrium points and stability.

Chapter 11

- Changed the introductory example in 11.1, which continues into 11.2, to avoid rounding issues.
- Added a new part (d) to Example 3 in 11.3, as well as Method 2 using a graphing calculator and Method 3 using a spreadsheet.
- Changed 11.3 so that graphing calculators are the primary method of calculating normal probabilities, and the normal table is the secondary method.

Chapter 12

- Revised Example 4 Method 1 (Graphing Calculator) in 12.1.
- Added clarification on the TVM Solver to Example 8 in 12.2.

Chapter 13

- In 13.1, revised coverage of translating graphs of sine and cosine functions. Also added a box to highlight the transformation of trigonometric functions.
- Added Example 8 to 13.2, which illustrates how to find the relative extrema for trigonometric functions.
- In 13.2, added new exercises (37–56), which use applications of the derivative applied to trigonometric functions. Applications include: critical numbers, intervals in which the function is increasing and decreasing, relative extrema, higher order derivatives, intervals in which the functions are concave upward and concave downward, inflection points, detailed graphs, absolute extrema, implicit differentiation, related rates, and differential approximation.

Features of *Calculus with Applications*

Chapter Opener

Each chapter opens with a quick introduction that relates to an application presented in the chapter.

Apply It

An Apply It question, typically at the start of a section, motivates the math content of the section by posing a real-world question that is then answered within the examples or exercises.

For Review

For Review boxes are provided in the margin as appropriate, giving students just-in-time help with skills they should already know but may have forgotten. For Review comments sometimes include an explanation, while others refer students back to earlier parts of the book for a more thorough review.

FOR REVIEW

Recall that $e^x > 0$ for all x , so there can never be a solution to $e^{g(x)} = 0$ for any function $g(x)$.

Caution

Caution notes provide students with a quick “heads up” to common difficulties and errors.

CAUTION

Notice from Example 5(c) that $g(x + h)$ is *not* the same as $g(x) + h$, which equals $-x^2 + 4x - 5 + h$. There is a significant difference between applying a function to the quantity $x + h$ and applying a function to x and adding h afterward.

Your Turn Exercises

These exercises follow selected examples and provide students with an easy way to quickly stop and check their understanding. Answers are provided at the end of the section’s exercises.

Technology Notes

Material on graphing calculators or Microsoft Excel is clearly labeled to make it easier for instructors to use this material (or not).

- **New** The figures depicting calculator screens now reflect the TI-84 Plus C, which features color and higher pixel counts.

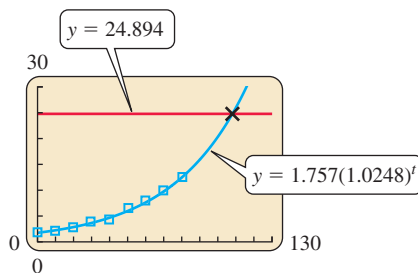






FIGURE 56

Exercise Sets

Basic exercises are followed by an Applications section, which is grouped by subheads such as “Business and Economics.” Other types of exercises include the following:

- **New Warm-Up** exercises at the beginning of most sections provide a chance for students to refresh the key prerequisite skills needed for the section’s exercises.
- **Connections** exercises integrate topics presented in different sections or chapters and are indicated with .

- **Writing** exercises, labeled with , provide students with an opportunity to explain important mathematical ideas.
- **Technology** exercises are labeled  for graphing calculator and  for spreadsheets.

Chapter Summary and Review

- The end-of-chapter **Summary** provides students with a quick summary of the key ideas of the chapter followed by a list of key definitions, terms, and examples.
- Chapter **Review Exercises** include Concept Check exercises and an ample set of Practice and Exploration exercises. This arrangement provides students with a comprehensive set of exercises to prepare for chapter exams.

Extended Applications

- Extended Applications are provided at the end of every chapter as in-depth applied exercises to help stimulate student interest. These activities can be completed individually or as a group project.

Supplements

FOR STUDENTS

Graphing Calculator Manual for Applied Mathematics (downloadable)

- Contains detailed instruction for using the TI-83/ TI-83+/ TI-84+C
- Instructions are organized by topic.
- Downloadable from within MyMathLab

Excel Spreadsheet Manual for Applied Mathematics (downloadable)

- Contains detailed instruction for using Excel 2013
- Instructions are organized by topic.
- Downloadable from within MyMathLab

FOR INSTRUCTORS

Instructor's Resource and Solutions Manual (Download Only)

- Provides complete solutions to all exercises, two versions of a pre-test and final exam, and teaching tips.
- Available to qualified instructors within MyMathLab or through the Pearson Instructor Resource Center (www.pearsonglobaleditions.com/lial).
- ISBN 1292109025 / 9781292109022

PowerPoint Presentations (Download Only)

- Includes lecture content and key graphics from the book.
- Available to qualified instructors within MyMathLab or through the Pearson Instructor Resource Center (www.pearsonglobaleditions.com/lial).
- ISBN 129210905X / 9781292109053

TestGen Computerized Test Bank

- 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.
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MyMathLab delivers **proven results** in helping individual students succeed.

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MyMathLab provides **engaging experiences** that personalize, stimulate, and measure learning for each student.

- **Personalized Learning:** MyMathLab offers several features that support adaptive learning: personalized homework and the adaptive study plan. These features allow your students to work on just what they need to learn when it makes the most sense, maximizing their potential for understanding and success.
- **Exercises:** The homework and practice exercises in MyMathLab are correlated to the exercises in the textbook, and they regenerate algorithmically to give students unlimited opportunity for practice and mastery. The software provides helpful feedback when students enter incorrect answers and includes optional learning aids including guided solutions, sample problems, animations, videos, and eText.
- **Learning and Teaching Tools** include:
 - **Learning Catalytics**—a “bring your own device” student engagement, assessment, and classroom intelligence system, included within MyMathLab. Includes questions written specifically for this course.
 - **Instructional videos**—full-length lecture videos as well as shorter example-based videos.
 - **MathTalk videos**—connect the math to the real world (particularly business). Also include assignable exercises to gauge student understanding of video content.

- **Help for Gaps in Prerequisite Skills**—diagnostic quizzes tied to personalized assignments help address gaps in algebra skills that might otherwise impede success.
- **Excel Spreadsheet Manual**—specifically written for this course.
- **Graphing Calculator Manual**—specifically written for this course.
- **Interactive Figures**—illustrate key concepts and allow manipulation for use as teaching and learning tools. Includes assignable exercises that require use of the figures.
- **Complete eText** is available to students through MyMathLab courses for the lifetime of the edition, giving students unlimited access to the eBook within any course using that edition of the textbook.

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- Knowing that you are using a Pearson product means knowing that you are using quality content. This means that our eTexts are accurate and our assessment tools work. It means we are committed to making MyMathLab as accessible as possible.
- Whether you are just getting started with MyMathLab, or have a question along the way, we're here to help you learn about our technologies and how to incorporate them into your course.
- To learn more about how MyMathLab combines proven learning applications with powerful assessment and continuously adaptive capabilities, visit www.mymathlab.com or contact your Pearson representative.

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Prerequisite Skills Diagnostic Test

Below is a very brief test to help you recognize which, if any, prerequisite skills you may need to remediate in order to be successful in this course. After completing the test, check your answers in the back of the book. In addition to the answers, we have also provided the solutions to these problems in Appendix A. These solutions should help remind you how to solve the problems. For problems 5-26, the answers are followed by references to sections within Chapter R where you can find guidance on how to solve the problem and/or additional instruction. Addressing any weak prerequisite skills now will make a positive impact on your success as you progress through this course.

1. What percent of 50 is 10?
2. Simplify $\frac{13}{7} - \frac{2}{5}$.
3. Let x be the number of apples and y be the number of oranges. Write the following statement as an algebraic equation: "The total number of apples and oranges is 75."
4. Let s be the number of students and p be the number of professors. Write the following statement as an algebraic equation: "There are at least four times as many students as professors."
5. Solve for k : $7k + 8 = -4(3 - k)$.
6. Solve for x : $\frac{5}{8}x + \frac{1}{16}x = \frac{11}{16} + x$.
7. Write in interval notation: $-2 < x \leq 5$.
8. Using the variable x , write the following interval as an inequality: $(-\infty, -3]$.
9. Solve for y : $5(y - 2) + 1 \leq 7y + 8$.
10. Solve for p : $\frac{2}{3}(5p - 3) > \frac{3}{4}(2p + 1)$.
11. Carry out the operations and simplify: $(5y^2 - 6y - 4) - 2(3y^2 - 5y + 1)$.
12. Multiply out and simplify $(x^2 - 2x + 3)(x + 1)$.
13. Multiply out and simplify $(a - 2b)^2$.
14. Factor $3pq + 6p^2q + 9pq^2$.
15. Factor $3x^2 - x - 10$.
16. Perform the operation and simplify: $\frac{a^2 - 6a}{a^2 - 4} \cdot \frac{a - 2}{a}$.