

Calculus

AND ITS APPLICATIONS



MARVIN L. BITTINGER

SEVENTH EDITION

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AND ITS APPLICATIONS

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MARVIN L. BITTINGER

Indiana University—Purdue University at Indianapolis



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*Football is like calculus.
Someone has to show you how to do it,
but once you've got er' figgered, why, she's easy.*

Bert Jones, Former quarterback, *Baltimore Colts*
(Bert Jones majored in mathematics in college.)

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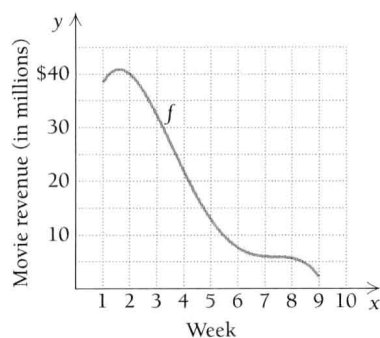
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Preface

Appropriate for a one-term course, this text is an introduction to calculus as applied to business, economics, the life and physical sciences, the social sciences, and many general areas of interest to all students. A course in intermediate algebra is a prerequisite for the text, although the appendix, *Review of Basic Algebra*, together with Chapter 1 provides a sufficient foundation to unify the diverse backgrounds of most students.



What's New in the Seventh Edition?

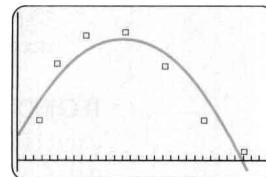
Functions Earlier

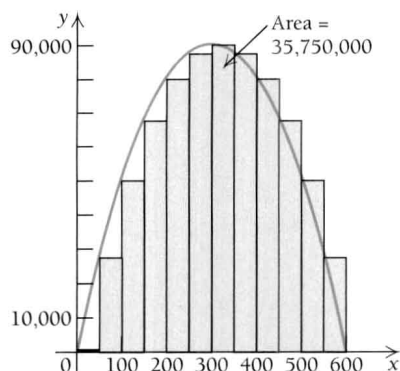
To minimize the amount of time needed for review, we have moved much of the algebra review material from Chapter 1 to an appendix. This allows us to begin Chapter 1 with coverage of functions, graphs, and models and to incorporate an earlier use of technology. New to this edition is Section 1.3, “Finding Domain and Range.” This early and expanded function coverage allows for many uses of functions such as the expansion of graphing applications.

Mathematical Modeling, Curve Fitting, and Regression

This edition continues its emphasis on mathematical modeling, including the advantages of technology as appropriate. For example, the use of the grapher for modeling, as an optional topic, is introduced in an all-new Section 1.6 and then reinforced many times throughout the text. (In this text, we use the term “grapher” to refer to all graphing calculators and graphing software.)

QuadReg
 $y = ax^2 + bx + c$
 $a = -.4868465035$
 $b = 25.94985182$
 $c = -238.4892193$





Integration Reorganized

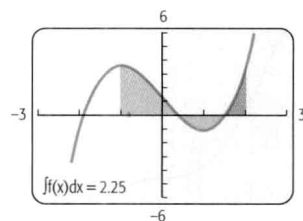
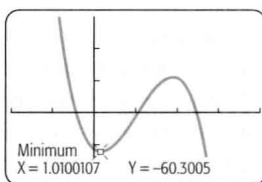
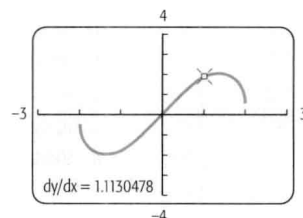
The structure of the material on integration in Chapter 5 has been significantly reorganized. Section 5.1 introduces antiderivatives and indefinite integrals. The topics of area and definite integrals are then connected in Section 5.2. Section 5.3 develops limits of sums and accumulations on an intuitive level and is now placed earlier in the chapter. In effect, what was covered in Sections 5.2, 5.3, 5.4, and 5.8 in the preceding edition is now reorganized and covered in Sections 5.2, 5.3, and 5.4.

Enhanced Technology

Though still optional, the use of technology has been expanded and enhanced.


TECHNOLOGY CONNECTION FEATURES. Technology Connection features (102 in all) are included throughout the text to illustrate the use of technology. Whenever appropriate, art that simulates graphs and tables generated using a grapher is included as well.

X	Y1	
12.3	1800.4	
13.3	2287.1	
14.3	2853.7	
15.3	3506.1	
16.3	4250.2	
17.3	5092.2	
18.3	6038	
X = 18.3		



There are now four types of Technology Connections for students and instructors to use for exploring key ideas in business calculus.

- *Lesson/Teaching.* These provide students with an example, followed by exercises to work.
- *Checking.* These tell the students how to verify a solution by using a grapher.
- *Exercises.* These are simply exercises for students to work using a grapher.
- *Exploration/Investigation.* These provide questions to guide students through an investigation.

TECHNOLOGY CONNECTION EXERCISES. Most exercise sets contain technology-based exercises that are indicated either with a  icon or under the heading “Technology Connection.” These exercises also appear in the Summary and Reviews and the

Chapter Tests. The Printed Test Bank supplement includes technology-based exercises as well.

Hallmark Features

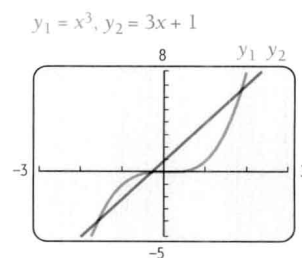
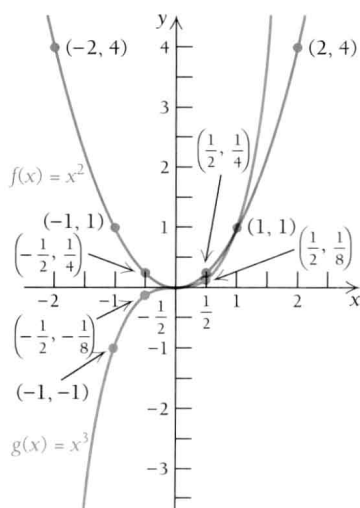
Student Friendly

Calculus and Its Applications, Seventh Edition, is the most student-oriented applied calculus text on the market. The level of vocabulary and terminology is accessible and used in a consistent manner, allowing the content to be easily understood by students. There is a plentiful supply of examples with numerous and carefully placed art pieces to help students visualize topics.

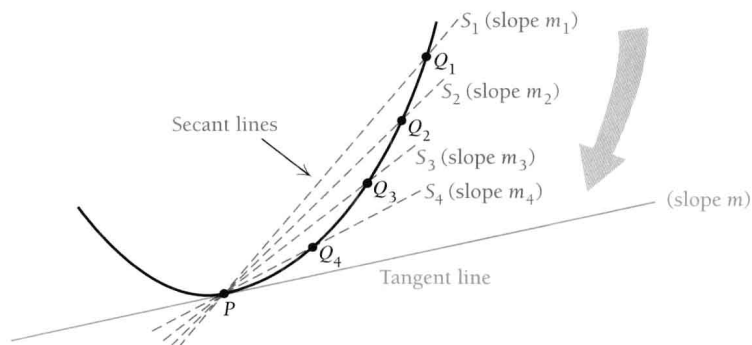
Use of Color

The text uses full color in an extremely functional way, and not merely as window dressing. Color usage has been carried out in a methodical and precise manner so that it enhances the readability of the text for the student and the instructor. The following illustrates.

For example, when two curves are graphed using the same set of axes, one is usually red and the other blue with the red graph the curve of major importance. This is exemplified in the following graphs from Chapter 1 (pp. 60 and 61). Note that the equation labels are the same color as the curve. When the instructions say “Graph,” the dots match the color of the curve.



In the following figure from Chapter 2 (p. 127), we see how color is used to distinguish between secant and tangent lines. Throughout the text, blue is used for secant lines and red for tangent lines.



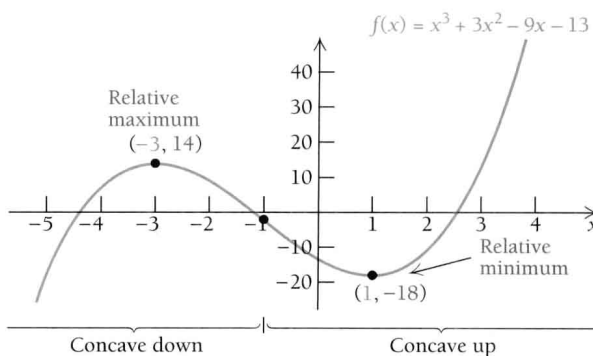
In the following graph and text development from Chapter 3 (pp. 205–206), the color red denotes substitution in equations and blue highlights maximum and minimum values (second coordinates). This specific use of color is carried out further, as shown in the figure that follows. Note that when dots are used for emphasis other than just merely plotting, they are black.

We then find second coordinates by substituting in the original function:

$$f(-3) = (-3)^3 + 3(-3)^2 - 9(-3) - 13 = 14;$$

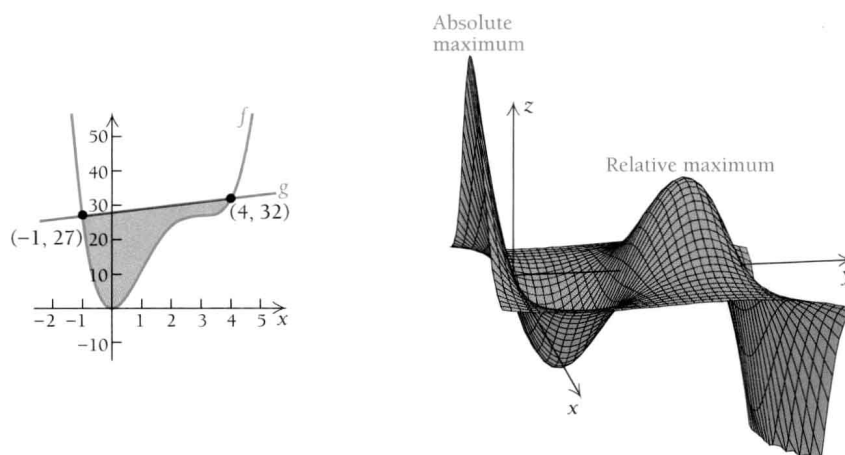
$$f(1) = (1)^3 + 3(1)^2 - 9(1) - 13 = -18.$$

Thus there is a relative maximum at $(-3, 14)$ and a relative minimum at $(1, -18)$. The relative extrema are shown in the graph below.



Beginning with integration in Chapter 5, the color amber is used to identify the area, unless certain special concepts are considered in the initial learning process.

The figure on the left below from Chapter 5 (p. 406) illustrates the vivid use of blue and red for the curves and labels, and amber for the area. In Chapter 7 (p. 513), we use extra colors for clarity. The top of the surface, as shown in the figure on the right below, is blue and the bottom of the surface is rose. This is carried out in all examples in Section 7.4.



Intuitive Approach

Although the word “intuitive” has many meanings and interpretations, its use here means “experience based.” Throughout the text, when a particular concept is discussed, its presentation is designed so that the students’ learning process is based on their earlier mathematical experience or a new experience presented by the author before the concept is formalized. This is illustrated by the following situations.

- The definition of the derivative in Chapter 2 is presented in the context of a discussion of average rates of change (see p. 116). This presentation is more accessible and realistic than the strictly geometric idea of slope.
- When maximum problems involving volume are introduced (see pp. 250–251), a function is derived that is to be maximized. Instead of forging ahead with the standard calculus solution, the student is first asked to stop, make a table of function values, graph the function, and then estimate the maximum value. This experience provides students with more insight into the problem. They recognize that not only do different dimensions yield different volumes, but also that the dimensions yielding the maximum volume may be conjectured or estimated as a result of the calculations.
- Relative maxima and minima (Sections 3.1–3.3) and absolute maxima and minima (Section 3.4) are covered in separate sections in Chapter 3, so that students obtain a gradual buildup of these topics as they consider graphing using calculus concepts (see pp. 186–249).
- The understanding behind the definition of the number e in Chapter 4 is explained both graphically and through a discussion of continuously compounded interest (see pp. 291–292).

Applications

Relevant and factual applications drawn from a broad background of fields are integrated throughout the text as applied problems and exercises, and are also featured in separate application sections. These have been updated and expanded in this edition, to include even more applications using real data. In addition, each chapter opener includes an application that serves as a preview of what students will learn in the chapter.

The applications in the exercise sets are grouped under headings that identify them as reflecting real-life situations:

Business and Economics
Life and Physical Sciences
Social Science
General Interest

This organization allows the instructor to gear the assigned exercises to a particular student and also allows the student to know whether a particular exercise applies to his or her major.

The following illustrate some examples of the applications.

- An early discussion in Chapter 1 of compound interest, total revenue, cost and profit, as well as supply and demand functions sets the stage for subsequent applications that permeate the book (see pp. 49, 153, and 254).
- The concepts of average rate of change and instantaneous rate of change are introduced with new business applications in Chapter 2. This is prior to the introduction of applications of differentiation in Chapter 3, which includes maximum–minimum applications (see pp. 249–265) and implicit differentiation and related rates (see pp. 273–279).
- When the exponential model is studied in Chapter 4, other applications, such as continuously compounded interest and the demand for natural resources, are also considered (see pp. 317–344). Growth and decay are covered in separate sections in Chapter 4 to allow room for the many worthwhile applications that relate to these concepts.
- Applications of integration are covered in a separate chapter and include a thorough coverage of continuous probability (see pp. 433–494).
- The Extended Technology Application feature includes interesting and topical situations such as the ecological effect of global warming (see pp. 91–93), predicting the distance a home run will travel (see pp. 181–183), and using total box-office revenue data to determine when videotape sales should begin (see pp. 360–362).

Pedagogical Features

Chapter Openers

Each chapter opener includes an application to whet the student's appetite for the chapter material. These applications also provide an intuitive introduction to a key calculus topic.

Section Objectives

As each new section begins, its objectives are stated in the margin. These can be spotted easily by the student, and they provide the answer to the typical question, “What material am I responsible for?”

Variety of Exercises

There are over 3300 exercises in this edition. The exercise sets are enhanced not only by the inclusion of business and economics applications, detailed art pieces, and extra graphs, but also by the following features.

- **TECHNOLOGY CONNECTION EXERCISES.** These exercises appear in the Technology Connection features (see pp. 34, 136, and 307) and in the exercise sets (see pp. 108, 234, and 400).
- **SYNTHESIS EXERCISES.** Synthesis exercises are included at the ends of most exercise sets and all Summary and Reviews and Chapter Tests. They require students to go beyond the immediate objectives of the section or chapter and are designed both to challenge students and to make them think about what they are learning (see pp. 174, 248, 332, and 407).
- **THINKING AND WRITING EXERCISES.** These exercises appear both in the exercise sets and in the synthesis section at the end of most exercise sets (see pp. 123, 234, and 386). They are denoted by the symbol **tw**. These ask students to explain mathematical concepts in their own words, thereby strengthening their understanding. The answers to these exercises are given in the *Instructor's Solutions Manual*.
- **APPLICATIONS.** A section of applied problems is included in most exercise sets. The problems are grouped under headings that identify them as business and economics, life and physical sciences, social sciences, or general interest. Each problem is accompanied by a brief description of its subject matter (see pp. 155–158, 349, and 397–398).

Tests and Reviews

- **SUMMARY AND REVIEW.** At the end of each chapter is a summary and review. These are designed to provide students with all the material they need for successful review. Answers are at the back of the book, together with section references so that students can easily find the correct material to restudy if they have difficulty with a particular exercise. In each summary and review there is a list of *Terms to Know*, accompanied by page references to help students key in on important concepts (see p. 279).
- **TESTS.** Each chapter ends with a chapter test that includes synthesis and technology questions. There is also a Cumulative Review at the end of the text that can also serve as a final examination. The answers, with section references to the chapter tests and the Cumulative Review, are at the back of the book. Six additional forms of each of the chapter tests and the final examination with answer keys appear, ready for classroom use, in the *Instructor's Manual/Printed Test Bank*.

Supplements for the Student

Student's Solutions Manual

ISBN 0-201-33865-3

Written by Judith A. Penna, this manual provides complete worked-out solutions for all odd-numbered exercises in the exercise sets (with the exception of the Thinking and Writing exercises). This supplement is available to instructors and is for sale to students.

Graphing Calculator Manual

ISBN 0-201-65863-1

The *Graphing Calculator Manual* by Judith A. Penna, with the assistance of Daphne Bell, contains keystroke level instruction for the Texas Instruments TI-83®, TI-83 Plus®, TI-85®, TI-86®, and TI-89® models. This manual is available to instructors and is for sale to students. Contact your Addison Wesley Longman sales consultant for a separate HP38G® module.

The *Graphing Calculator Manual* uses actual examples and exercises from *Calculus and Its Applications*, Seventh Edition, to teach students to use a graphing calculator. The order of topics in the *Graphing Calculator Manual* mirrors that of the text, providing a just-in-time mode of instruction.

Web Site

The Web site for this text provides additional resources for both students and instructors.

Supplements for the Instructor

Instructor's Solutions Manual

ISBN 0-201-66977-3

The *Instructor's Solutions Manual* by Judith A. Penna contains worked-out solutions to *all* exercises in the exercise sets. This supplement is available to instructors.

Instructor's Manual/Printed Test Bank

ISBN 0-201-66976-5

The *Instructor's Manual/Printed Test Bank* (IM/PTB) by Laurie Hurley contains six alternate test forms for each chapter test and six comprehensive final examinations with answers. The IM/PTB also has answers for the even-numbered exercises in the exercise sets. These can be easily copied and handed out to students. The answers to the odd-numbered exercises are at the back of the text.

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TestGen-EQ's friendly graphical interface enables instructors to easily view, edit, and add questions, transfer questions to tests, and print tests in a variety of fonts and forms. Search and sort features let the instructors quickly locate questions and

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Consult your Addison-Wesley representative for details.

Supplementary Chapters

ISBN 0-201-65864-X

The trigonometry chapter, Chapter 8 in the preceding edition, has been deleted from this text. It is available as a supplement to this edition. Also available are supplemental chapters, written by Marvin L. Bittinger and Michael A. Penna of Indiana University—Purdue University at Indianapolis, that present material on sequences and series and expand the book’s presentation of differential equations. Many applications, along with optional technology material, are included. All three chapters are available together as a single paperback supplement.

Acknowledgments

Your author has taken many steps to ensure the accuracy of the manuscript. The graphic art pieces have been computer-generated. A number of devoted individuals comprised the team that was responsible for monitoring each step of the production process in such careful detail. In particular, I would like to thank Judith A. Beecher and Judith A. Penna for their helpful suggestions, proofreading, and checking of the art. Their efforts above and beyond the call of duty deserve infinite praise. I also wish to express my appreciation to my students for providing suggestions and criticisms so willingly during the preceding editions; to Mike Penna of IUPUI for his help with the computer graphics; and to Daphne Bell, Barbara Johnson, Judy Penna, Bill Saler, and Keith Schwingendorf for their precise checking and proofreading of the manuscript for mathematical accuracy. In addition, I would like to thank Scott Mortensen and Ken Hurley for their contributions to the technology material.

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Index of Technology Connections

The following index lists, by topic, 64 optional Technology Connections. These features incorporate in-text comments, including guided explorations and exercises, that explain and encourage the use of technology to explore problem situations. The Technology Connection Features, along with the Technology Connection Exercises in the exercise sets, and the Extended Technology Applications, described in the Preface, bolster the optional integration of technology into the course. New to this edition is a *Graphing Calculator Manual*, available for students, featuring keystroke instructions for several calculator models.

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