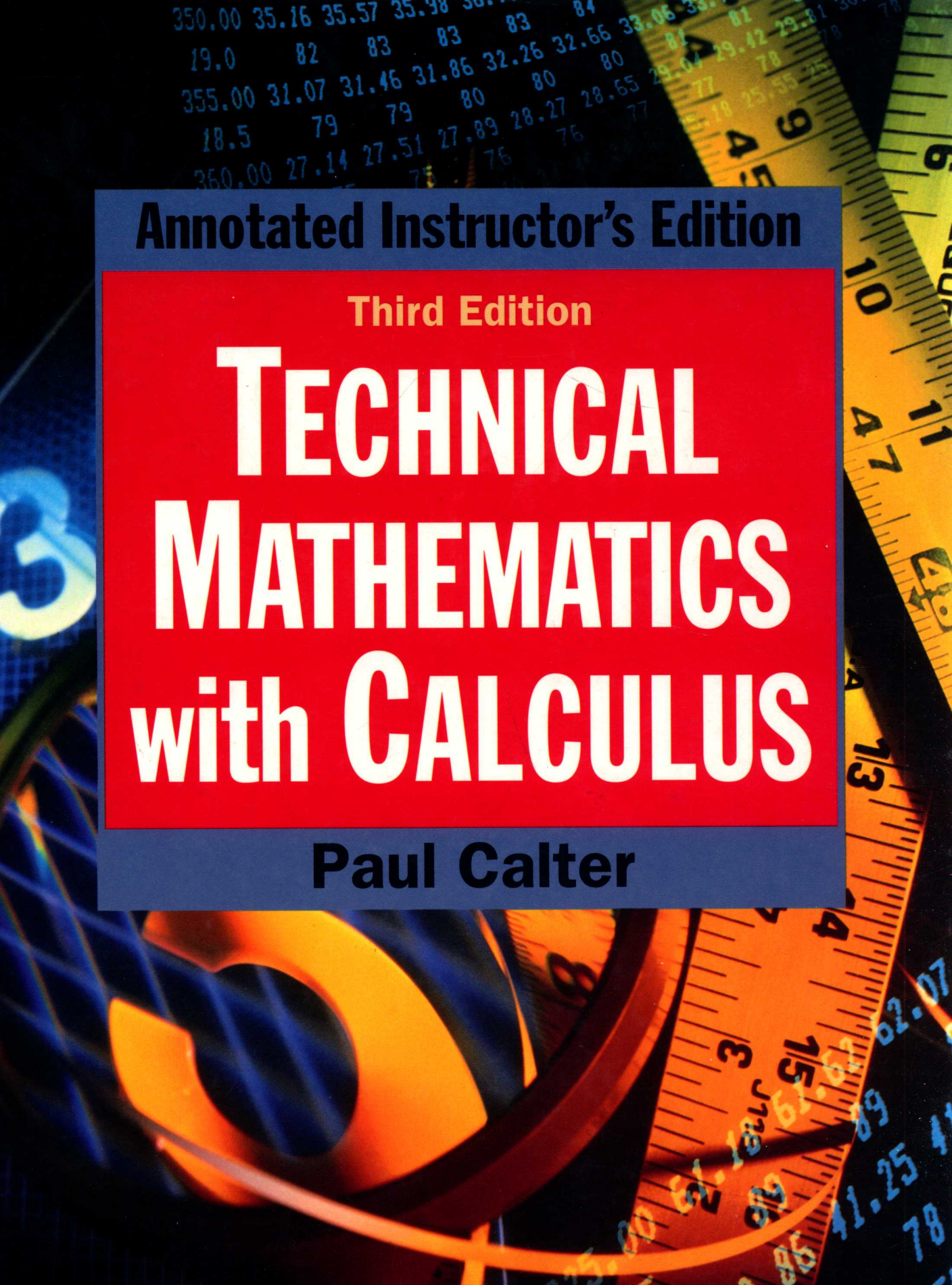

Annotated Instructor's Edition

Third Edition

TECHNICAL MATHEMATICS with CALCULUS

Paul Calter

THIRD EDITION

Technical Mathematics with Calculus

Paul Calter
Professor of Mathematics
Vermont Technical College

Annotated Instructor's Edition

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To Margaret Jolind

Preface

Technical Mathematics with Calculus, third edition, is intended for students at technical schools or two-year technical colleges. Depending on the pace and the amount of material included, it may be used for either a two- or three-semester course.

Possibly the greatest change in the teaching of mathematics that has taken place since the publication of the second edition of this text is the wide adoption of the graphics calculator. We have modified our presentation accordingly, with the graphics calculator thoroughly integrated into the book, both in the text and in the exercises. We have, however, still retained most of the former methods, such as manual graphing by plotting of point pairs, for those classes not using the graphics calculator. Other new features include estimation of answers, team projects, and the use of computer algebra systems. In addition to introducing new features, the aim of the revision was to respond to comments and suggestions made by many reviewers and colleagues and to make improvements that occurred to the author while teaching from the second edition. We also tried to follow as closely as possible the NCTM Standards and Guidelines and the AMATYC Position Statement on Undergraduate Textbooks.

Features of the Book

A mathematics book is never easy reading, so much care has gone into making the material as clear as possible. We follow an intuitive rather than a rigorous approach and give information in small segments. Numerous illustrations and careful page layout are designed to make the material as easy to follow as possible. The book also has the following features. **Chapter Objectives** start each chapter. They state specifically what the student should be able to do upon completion of the chapter. Many fully worked **Examples** form the backbone of the textbook. They are particularly chosen to help the student to do the exercises. We have added dozens of examples to supplement those in the second edition. Examples have markers above and below to separate them clearly from the text discussion.

Practice is essential for learning mathematics, as with other skills, and so we include thousands of **Exercises.** Exercise sets are indicated by title, as

well as by number, to further help the student find things in the book. Exercises given after each section are graded by difficulty and grouped by type, to allow practice on a particular area. However those given in the **Chapter Review Problems** are scrambled as to type and difficulty. Answers to all odd-numbered problems are given in the **Answer Key** in the Appendix, and answers to every problem are given in the **Annotated Instructor's Edition.** Complete solutions to every problem are contained in the **Instructor's Solutions Manual,** and more detailed solutions for every other odd problem are given in the **Student Solutions Manual.**

All important **Formulas,** both mathematical and technical, are boxed and numbered in the text. We also list these formulas in the Appendix as the **Summary of Facts and Formulas.** This listing can function as a "handbook" for a calculus course and for other courses as well, and provides a common thread among chapters. We hope it will also help students to see interconnections that might otherwise be overlooked. The formulas are grouped logically in the Summary of Facts and Formulas and are numbered sequentially there. Therefore, the formulas do not necessarily appear in numerical order in the text.

Marginal notes are used for encouragement, to give historical notes, for reminders of things already covered, for peeks ahead at things to come, and so forth.

An instructor quickly learns the pitfalls and traps that "get" students year after year. Many of these are noted in the text as **Common Error Boxes.**

We include discussions in the text of many **technical applications,** such as the use of mathematics for analyzing motion, or for electric circuits. They are included for classes that wish to cover those topics, as well as for motivation, to show that mathematics has real uses. Because space does not permit a full discussion of each application, judgment must be used in assigning applications problems. It is not intended that every student be able to solve every application. We assume that students have sufficient background before attempting the more difficult problems in their own technical area and that they will get technical help not offered in this text. The **Index to Applications** should help in finding specific applications.

The **writing across the curriculum** movement among mathematics educators aims to use writing to help teach mathematics. One difficulty in implementing this idea is the lack of good writing questions, so we have provided one such question per chapter. These will give the instructor something to assign, and also indicate the kinds of questions that can be used so that the instructor can make up others.

New Features

The **graphics calculator** has been fully integrated throughout. The chapter called "Functions and Graphs" in the second edition has been split into two chapters, with an entire chapter now devoted to graphing. A new introductory section for the graphics calculator is given in this chapter. Thereafter calculator instruction and examples are given in the text, where appropriate, and calculator problems are given in the exercises. Many problems are given that can be practically solved *only* by graphics calculator, and the graphics

calculator is sometimes used to verify a solution found by another method. There is a new section on graphing **parametric equations.** Finally, the third edition has been made even more visual than the heavily illustrated second edition with many **additional illustrations.**

Students have never been reluctant to put down a preposterous answer (i.e., the cost of the shirt is $450). In this edition we have tried to show students how to **estimate an answer** in order to check their work. An introductory section on estimating an answer is given as one of the steps in solving a word problem, when word problems are introduced in Chapter 3. Thereafter, almost every applications example begins with an estimation step or ends with a **check for reasonableness** of the answer.

The trend is away from contrived "school" problems with neat solutions and toward **problems with approximate solutions,** that do not yield to many of the methods we teach. These include expressions and equations with approximate constants, and problems that cannot be solved exactly but must be tackled with an approximate method. We include many **numerical methods for the computer,** but these topics are included in such a way so that they can be skipped without impairing the overall study of technical mathematics. Those calculations that are best done by computer are given in the text itself. Elsewhere, computer problems are suggested at the end of exercises, as enrichment activities. Some numerical methods we give are finding roots of equations by the midpoint method, by the false position method, and by simple iteration; solving systems of equations by the Gauss–Seidel method, and by matrix inversion; evaluation of determinants by the method of Chio; numerical evaluation of power series, Fourier series, and limits; numerical differentiation and integration; numerical solution of differential equations, and so forth.

To the existing computer problems using BASIC and spreadsheets, we have added **computer algebra systems** or **CAS.** This material has been placed in the text where appropriate, but more often included in the Exercises. We have given the commands for the three most popular systems, Derive, Maple, and Mathematica. CAS is much less available to students than the graphics calculator, hence our treatment here is less inclusive.

There continues to be interest in collaborative learning, where students work in groups. To provide material for the instructor who wishes to try an occasional group project, we give an introductory Project in Chapter 1 and thereafter have placed **Team Projects** at the end of nearly every chapter. These will also serve as models for Team Projects that the teacher and student can make up themselves. Some of the more complicated team projects are accompanied by a **Teaching Tip** in the AIE.

One aspect of the **Harvard calculus** approach is that each new idea should be presented graphically, numerically, and analytically. We have followed this approach wherever feasible. The derivative, for example, is introduced graphically and numerically, before its analytical treatment in the remainder of the chapter. Some examples even have multiple solutions. Where appropriate, a summary is given of the different methods available to solve a certain type of problem.

There have been a few changes in organization, such as the splitting of the chapter on Functions and Graphs already mentioned. The former chapters on the Straight Line and the Conic Sections have been combined into a

single chapter, Analytic Geometry, as is the practice in many other texts. The overly long treatment of the straight line has been reduced, with some of this material moved to the new chapter on graphing. The new combined chapter has been moved forward in response to reviewers who wanted it sooner. The chapter on Statistics has been expanded to include **process control, regression,** and the **method of least squares.**

The chapters on the Indefinite Integral and the Definite Integral have been combined into a single chapter, Integration, allowing for a more coherent development. The long chapter on Applications of the Integral has been split into two chapters. Finally, in response to many reviewers, Derivatives of the Logarithmic, Trigonometric, and Exponential Functions has been placed later in the text. This more difficult material can now be covered after the basic ideas of calculus have been presented.

Teaching Resources

There are supplements to aid both the instructor and the student. An **Annotated Instructor's Edition** (AIE) of this text contains answers to every exercise and problem. The answers are placed in red right in the exercise or problem. The AIE also has red marginal notes to the instructor, giving teaching tips, applications, and practice problems.

An **Instructor's Solution Manual** contains worked out solutions to every problem in the text and listing of all computer programs. The **Student Solutions Manual** gives the solution to every other odd problem. They are usually worked in more detail than in the Instructor's Solution Manual.

A **Computerized Test Item File** by Michael Calter is a bank of test questions with answers. Questions may be mixed, sorted, changed, or deleted. It consists of a test file disk and a test generator disk, ready to run. A **Computer Solutions Disk,** also by Michael Calter contains each program from the text. **Transparency acetates**, giving additional problems and full explanations, are available.

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Randolph, Vermont

About the Author

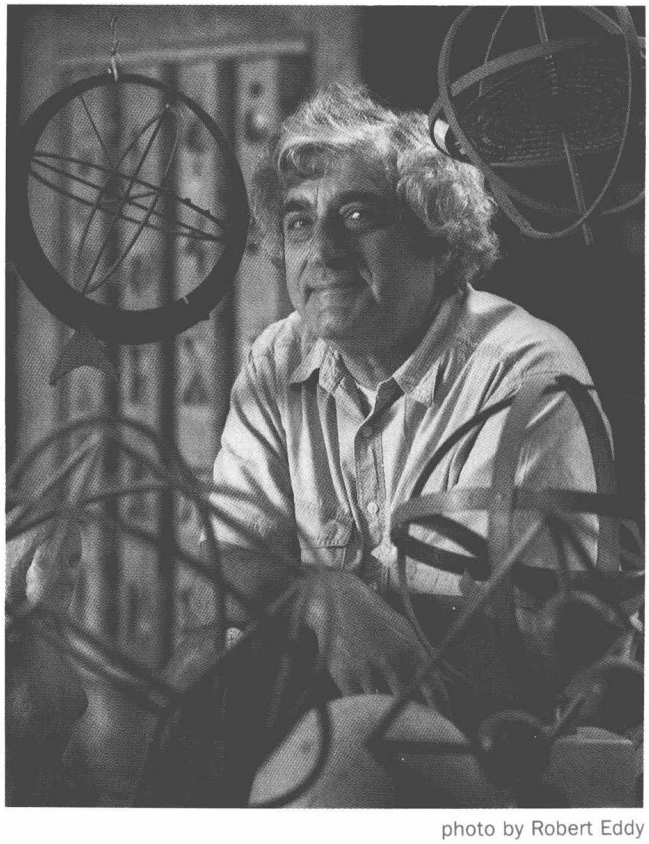
Paul Calter is Professor of Mathematics at Vermont Technical College. A graduate of The Cooper Union, New York, he received his M.S. from Columbia University.

Professor Calter, a member of the American Society of Mechnical Engineers has been teaching Technical Mathematics for over twenty-five years. In 1987, he was the recipient of the Vermont State College Faculty Fellow Award.

A member of the American Mathematical Association of Two Year Colleges, Professor Calter is the Director of the AMATYC Summer Institute in Vermont. He is also a member of the Mathematical Association of America, the National Council of Teachers of Mathematics, the International Society for the Arts, Sciences, and Technology, Volunteers in Technical Assistance, and the Author's Guild.

Professor Calter is the author of several mathematics textbooks, among which are the Schaum's Outline of Technical Mathematics. With Prentice Hall he has published three other books: *Practical Math Handbook for the Building Trades, Mathematics for Computer Technology,* and *Technical Calculus*.

He resides in rural Vermont and is an accomplished sculptor; he has large pieces installed at several locations, including the Montshire Museum of Science and Vermont Technical College. His work often reflects themes related to mathematics.



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1

Numerical Computation

OBJECTIVES

When you have completed this chapter, you should be able to:

- Perform basic arithmetic operations on signed numbers.
- Perform basic arithmetic operations on approximate numbers.
- Take powers, roots, and reciprocals of signed and approximate numbers.
- Perform combined arithmetic operations to obtain a numerical result.
- Convert numbers between decimal and scientific notation.
- Perform basic arithmetic operations on numbers in scientific notation.
- Convert units of measurement from one denomination to another.
- Substitute given values into equations and formulas.
- Solve common percentage problems.

TEACHING TIP: The topics of this first chapter may seem very different from one section to another. This is to be expected since we are selecting those numerical concepts that will help us in later chapters.
Please keep in mind that this chapter is intended as a fast review of material that students are expected to know upon entering a Technical Mathematics course. We are not trying to teach basic arithmetic here. Pick and choose from these topics, as needed, or skip them entirely. Some instructors have their students scan this chapter on their own, and start teaching from Chapter 2.

In this first chapter we cover ordinary arithmetic, but in a different way. The basic operations are explained here in terms of the *calculator*. Although the calculator makes arithmetic easier than before, it also introduces a complication: that of knowing how many of the digits shown in a calculator display should be kept. We will see that it is usually incorrect to keep them all. Then, after performing the algebraic operations on pairs of numbers, we will show how to link these operations to evaluate more complex expressions.

Also in this chapter, we will learn some rules that will help us when we get to algebra.

We also learn *scientific notation*—a convenient way to handle very large or small numbers without having to write down lots of zeros. It is also the way in which calculators and computers display such numbers.

We then consider the *units* in which quantities are measured: how to convert from one unit to another, and how to substitute into equations and formulas and have the units work out right.

Next we learn how to substitute values into equations and formulas and to evaluate the result, an operation of great practical importance in technical work.

Finally, we cover *percentage*, one of the most often used mathematical ideas in technology as well as in everyday life.