MATHEMATICS

ITS POWER AND UTILITY

KARL J. SMITH

5TH EDITION

MATHEMATICS
Its Power and Utility

FIFTH EDITION

Karl J. Smith
Santa Rosa Junior College

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I dedicate this book with love
to my son, Shannon,
and his bride, Jane.

Preface

• When we learn to drive a car we are able to "go places" easily and pleasantly instead of walking to them with a great deal of effort. And so you will see that the more mathematics we know the easier life becomes, for it is a tool with which we can accomplish things that we could not do at all with our bare hands.

Lillian R. Lieber,
The Education of T. C. Mitts

ORGANIZATION OF THIS BOOK

The main theme throughout this book is *problem solving*. We begin the first part, "The Power of Mathematics," by discussing math anxiety and how to formulate the problem. The most difficult first step for many students is to determine exactly the nature of the problem. All too often students try to solve a problem before they are even sure what they are trying to solve. Techniques from arithmetic, algebra, and geometry are all applied to problem solving.

These techniques of problem solving are then used in the second part of the book, "The Utility of Mathematics." Each topic in this part of the book was selected because of its usefulness to the student. The topics include managing money using the ideas of interest, installment buying, credit cards, inflation, buying a car or home, sets, probability, contests, statistics, surveys, and the influence of these topics on our lives.

The material of this book can be adapted to almost any course arrangement. Chapter 1 on calculators and arithmetic is required for the rest of the book, but it may be treated lightly or skipped by those familiar with its contents. Topics from beginning algebra are presented in Chapters 2, 3, and 4 and are then used in developing much of the material that follows. For example, percents in Chapter 5 are described with proportions and simple equations. Chapter 6 introduces the ideas of geometry and measurement in a practical, down-to-earth manner. Chapters 7–11 give the students a chance to use mathematics in a variety of ways, including interest, consumer applications, sets, logic, probability, statistics, and graphs. I have written this book with the idea that different classes will pick different topics as interest and competency requirements dictate. These chapters are independent and can be covered in any order.

PROBLEM SOLVING

Many books pay lip service to problem solving, but I believe problem solving involves real-world problems in which assumptions must be made, superfluous information disregarded, and on occasion, additional information sought. This is difficult to implement in a textbook. In this book, I begin each section in the second

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part with a SITUATION, usually a dialogue in which a question is posed. Then in the section we develop the necessary mathematics to answer the question, and, finally, the last two problems of the section return to the SITUATION. First, the student is asked to answer the question posed. For example:

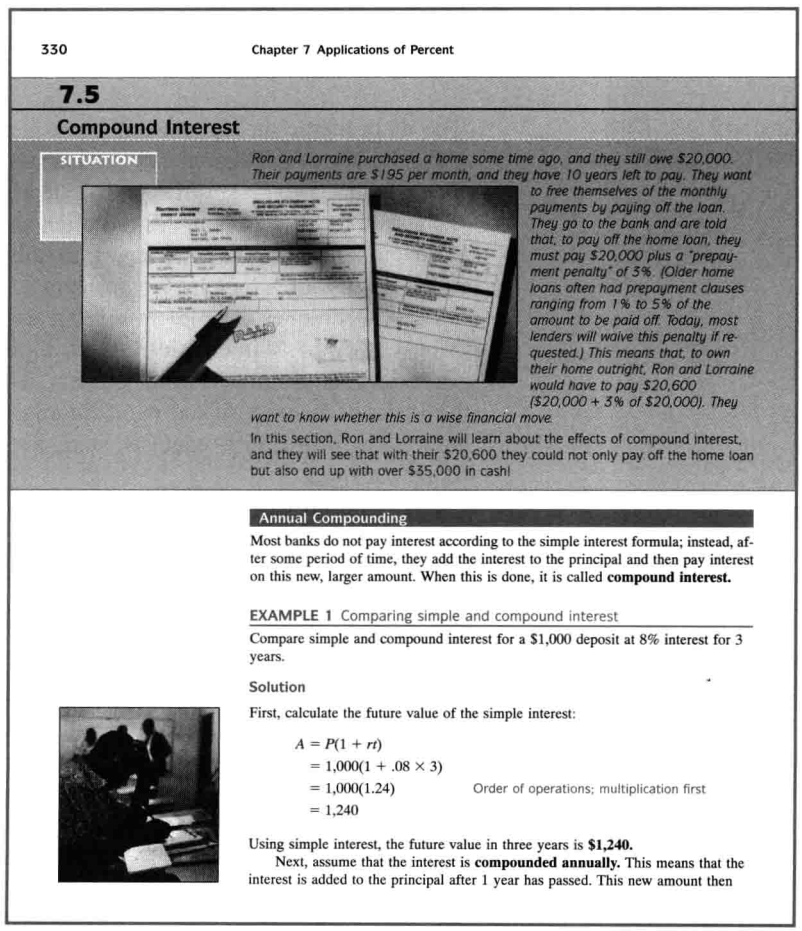
Page 296 • Has enough been saved for a purchase?

Page 304 • How much is needed for your retirement?

Page 314 • What is APR?

Page 323 • Does it matter which credit card you use?

Page 330 • When should you pay off a home loan?



330 Chapter 7 Applications of Percent

7.5

Compound Interest

SITUATION

Ron and Lorraine purchased a home some time ago, and they still owe $20,000. Their payments are $195 per month, and they have 10 years left to pay. They want to free themselves of the monthly payments by paying off the loan. They go to the bank and are told that, to pay off the home loan, they must pay $20,000 plus a "prepayment penalty" of 5%. (Older home loans often had prepayment clauses ranging from 1% to 5% of the amount to be paid off. Today, most lenders will waive this penalty if requested.) This means that, to own their home outright, Ron and Lorraine would have to pay $20,600 ($20,000 + 5% of $20,000). They want to know whether this is a wise financial move.

In this section, Ron and Lorraine will learn about the effects of compound interest, and they will see that with their $20,600 they could not only pay off the home loan but also end up with over $35,000 in cash!

Annual Compounding

Most banks do not pay interest according to the simple interest formula; instead, after some period of time, they add the interest to the principal and then pay interest on this new, larger amount. When this is done, it is called **compound interest.**

EXAMPLE 1 Comparing simple and compound interest

Compare simple and compound interest for a $1,000 deposit at 8% interest for 3 years.

Solution

First, calculate the future value of the simple interest:

$$\begin{aligned} A &= P(1 + rt) \\ &= 1{,}000(1 + .08 \times 3) \\ &= 1{,}000(1.24) \qquad \text{Order of operations; multiplication first} \\ &= 1{,}240 \end{aligned}$$

Using simple interest, the future value in three years is **$1,240.**

Next, assume that the interest is **compounded annually.** This means that the interest is added to the principal after 1 year has passed. This new amount then

Page 342 • How much down payment is necessary to purchase a particular home as a function of your salary?

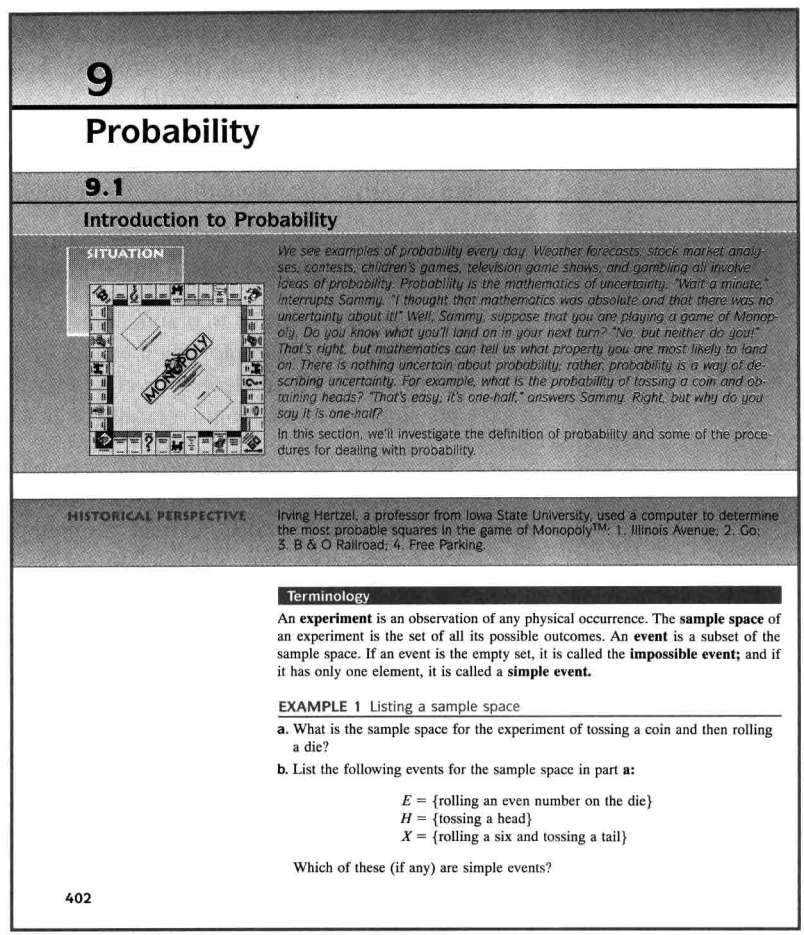
Page 361 • Is the infinite plausible?

Page 370 • Barber's Rule: Darryl shaves those men and only those men who do not shave themselves. Does Darryl shave himself?

Page 376 • Why didn't Matt obtain a job in which he faked a survey?

Page 384 • What was thrown off the bridge in the song "Ode to Billy Joe"?

Page 402 • On which property in MONOPOLY ™ are you most likely to land?



9

Probability

9.1

Introduction to Probability

SITUATION

We see examples of probability every day. Weather forecasts, stock market analyses, contests, children's games, television game shows, and gambling all involve ideas of probability. Probability is the mathematics of uncertainty. "Wait a minute," interrupts Sammy, "I thought that mathematics was absolute and that there was no uncertainty about it!" Well, Sammy, suppose that you are playing a game of Monopoly. Do you know what you'll land on in your next turn? "No, but neither do you!" That's right, but mathematics can tell us what property you are most likely to land on. There is nothing uncertain about probability; rather, probability is a way of describing uncertainty. For example, what is the probability of tossing a coin and obtaining heads? "That's easy, it's one-half," answers Sammy. Right, but why do you say it is one-half?

In this section, we'll investigate the definition of probability and some of the procedures for dealing with probability.

HISTORICAL PERSPECTIVE

Irving Hertzel, a professor from Iowa State University, used a computer to determine the most probable squares in the game of Monopoly™: 1. Illinois Avenue; 2. Go; 3. B & O Railroad; 4. Free Parking.

Terminology

An **experiment** is an observation of any physical occurrence. The **sample space** of an experiment is the set of all its possible outcomes. An **event** is a subset of the sample space. If an event is the empty set, it is called the **impossible event;** and if it has only one element, it is called a **simple event.**

EXAMPLE 1 Listing a sample space

a. What is the sample space for the experiment of tossing a coin and then rolling a die?

b. List the following events for the sample space in part **a:**

E = {rolling an even number on the die}
H = {tossing a head}
X = {rolling a six and tossing a tail}

Which of these (if any) are simple events?

402

Page 415 • How likely are you to win a free hamburger in a McDonald's contest?

Page 427 • Would you gamble with your friend George?

Page 443 • Which TV and magazine advertisements have fallacies?

Page 457 • How could Orville and Wilbur have known that wind conditions in Kitty Hawk were unsuitable?

Page 469 • What does it mean for a teacher to "grade on a curve"?

Page 474 • How can you tell whether a coin is fair?

Page 483 • How are locations on a map indicated?

Page 489 • How could Tom and Huck determine the depth of a well without climbing down?

Page 495 • How is it possible to designate a precise location in a room?

Page 500 • How can Linda determine the least cost for a car rental?

Page 508 • About 20 years ago, a daredevil named Evel Knievel attempted a skycycle ride across the Snake River. How could he be sure that he would make it?

A follow-up essay question asks the student to write about why the SITUATION is like or unlike something that might or might not happen in his or her own life.

FEATURES AND TEACHING AIDS

Many features are included in this edition to help with understanding of the material:

- This book is devoted to practical information rather than abstract made-up word problems. For example, when we are looking at graphs, we consider graphs showing the blood alcohol level and its effects when driving (page 453). We consider actual economic graphs (page 453) taken from a newspaper.
- We seek to develop higher-order reasoning in which the student needs to use, explain, and exploit newly learned knowledge, *outside the classroom.* For example, the Santa Rosa street problem puts the Königsberg bridge problem in a contemporary setting (pages 246–247).
- One of the most avoided topics in mathematics textbooks is *estimation.* Many of the problem sets have multiple-choice questions (page 31). Note that estimation is a listed objective in almost every chapter, and these tend to be practical in nature (see page 354).
- There is an emphasis on developing a money sense (see Chapter 7).
- There are specially designed features to develop critical thinking and communication skills. In particular, there are problems that solicit a written paper (page 239, for example, requests an essay discussing the student's opinion about using the metric measurement system), or a book report (page 478). Problems designated IN YOUR OWN WORDS encourage students to communicate mathematical ideas by using their own words. Students need to be able to *communicate* in mathematics, and should not stop after they can "find a few right answers." For example, we analyze the lyrics of "By the Time I Get to Phoenix" (see page 394), and look for the errors in Anacin (page 479) and Saab advertisements (see page 456).
- New terms are given in **boldface.**
- ⊘ WARNINGS are noted with a special logo. ⊘
- DEFINITIONS and procedures are boxed.

J. Sargeant Reynolds Community College; Sandra Manigault, *Northern Virginia Community College–Annendale Campus*; DeAnne Miller, *Western New Mexico University*; Mary Anne C. Petruska, *Pensacola Junior College*; Richard Watkins, *Tidewater Community College.*

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The production staff at Brooks/Cole also deserves special credit. In particular, Craig Barth was most helpful not only in doing extensive market research for this book, but also in suggesting material and for taking an active part in the development of the first edition of this book. I would also like to thank my current editor, Bob Pirtle, for his involvement.

Susan Reiland, the production editor, has gone above and beyond what was required of her in helping me prepare this manuscript for publication. Her work, as always, was impeccable. Special thanks go also to my accuracy checkers, Diana Gerardi and Jean Woody, who not only read every word (several times) and worked every problem, but also took a personal interest in making this the best possible book.

KARL J. SMITH

- CALCULATOR COMMENTS are enclosed in specially designed boxes, and CALCULATOR PROBLEMS are included in many problem sets.
- Examples are set apart and designated by an endmark.
- Arrows and *author's notes* are included to help students through a difficult process.
- HISTORICAL PERSPECTIVES are used at the beginning of each section in the first part of the book. They are included to personalize mathematics. For example, see the historical perspective on Bill Gates (p. 261).
- SITUATIONS are used to motivate each section in the second part of the book.
- MIND BOGGLERS are used to present interesting and challenging problems in the first part of the book (see pages 15 and 32).
- Newspaper clippings are included to keep the material contemporary.
- **What is wrong...** problems are included in most problem sets. These problems focus on common mistakes and build the student's communication skills. The answers to *all* of these problems are given in the back of the book because these common mistakes *must* be avoided by the students.
- Chapter reviews are extensive; their special design includes terms, objectives, self-test, self-test answers, and supplementary problems.

There is an *Instructor's Manual,* which includes the answers to all of the problems (including graphs) in the book. A separate *Test Manual* is also available in hard copy as well as on disk in Mac/Windows/DOS formats.

WHAT IS NEW TO THIS EDITION

I have been gratified by the positive response to all four of the previous editions. Although most users and reviewers offered only minor suggestions for this edition, I have added many more historical perspectives, as well as many more problems asking the student to explain important concepts and ideas in their own words. A glossary of important terms has also been added to this edition. Finally, there are two new appendices, one on the Hindu–Arabic numeration system and another on different numeration systems.

ACKNOWLEDGMENTS

I am most grateful to those who have assisted me in the development of this material: to my students who made many valuable suggestions about the material, and especially to those students who were bold enough to share their fears and anxieties with me; to my colleagues who shared ideas and teaching suggestions; and to the reviewers who offered many valuable suggestions. In particular, I would like to thank:

Mari Jo Baker, *Illinois Central College*; John Beris; Rebecca Farrow, *John Tyler Community College*; Margaret Finster, *Erie Community College*; Dorothy Johnson, *Cleveland State University*; Lara Langdon; Ann Loving,

MATHEMATICS

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PART 1

FOUNDATIONS:

The Power of Mathematics

1
Arithmetic, Calculators, and Problem Solving

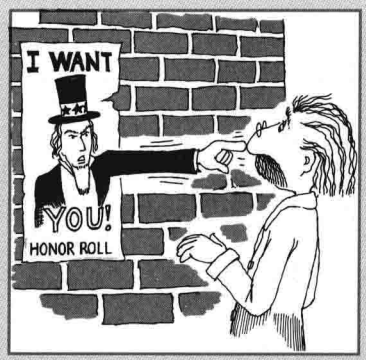
2
Sets of Numbers

3
Introduction to Algebra

4
Percents and Problem Solving

5
Introduction to Geometry

6
Measurement and Problem Solving



Historically, the prime value of mathematics has been that it enables us to answer basic questions about our physical world, to comprehend the complicated operations of nature, and to dissipate much of the mystery that envelops life. The simplest arithmetic, algebra, and geometry suffice to determine the circumference of the earth, the distances to the moon and the planets, the speeds of sound and light, and the reasons for eclipses of the sun and moon. But the supreme value of mathematics, insofar as understanding the world about us is concerned, is that it reveals order and law where mere observation shows chaos . . . .

MORRIS KLINE—*Mathematics: An Introduction to Its Spirit and Use,* San Francisco: W. H. Freeman, 1979, p. 1.

The first part of this book, "The Power of Mathematics," attempts to develop an appreciation for mathematics by displaying the intrinsic **power** of the subject. We will begin by looking at some of the causes and effects of *math anxiety*. We take natural steps—small at first, and then a little larger as you gain confidence— to review and learn about calculators, fractions, percents, algebra, equations, metrics, and geometry.

Most people view mathematics as a series of techniques useful only to the scientist, the engineer, or the specialist. In fact, the majority of our population could be classified as math-avoiders, who consider the assertion that mathematics can be creative, beautiful, and significant not only as an "impossible dream," but also something they don't even want to discuss.

At each turn of the page, I hope you will find something new and interesting to you. I want you to participate and become involved with the material. I want you to experience what I mean when I speak of the *beauty* of mathematics. I hope you are now ready to begin your study of a new course; I wish you success.

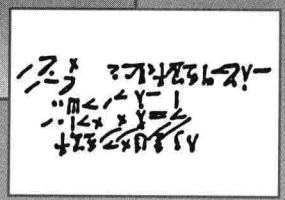
1

Arithmetic, Calculators, and Problem Solving

1.1

Math Anxiety

HISTORICAL PERSPECTIVE



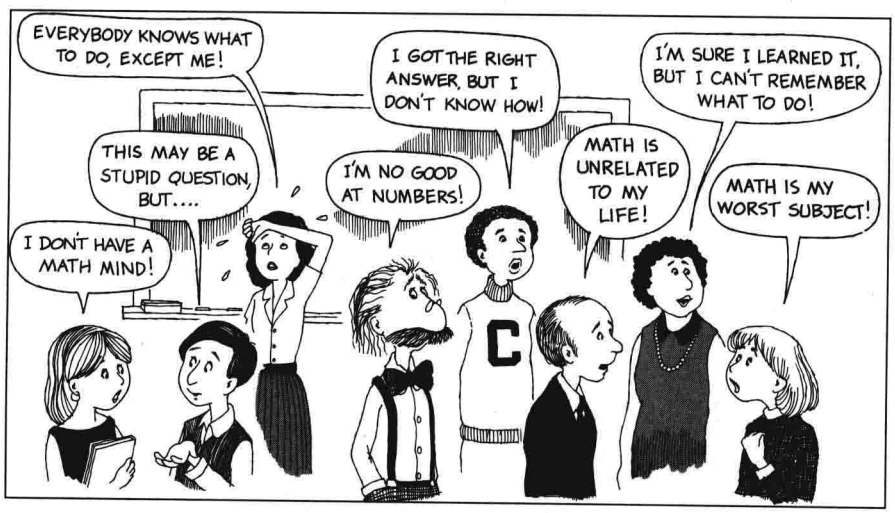
Rhind Papyrus (ca 1575 B.C.): Ancient mathematical problems

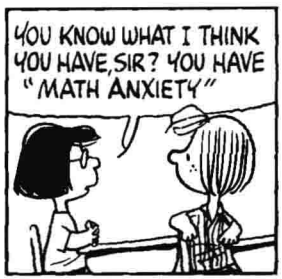
The history of mathematics can be divided into six periods:

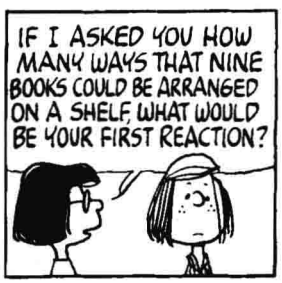
Chinese/Egyptian/Babylonian Period:	3000 B.C. to 601 B.C.
Greek Period:	600 B.C. to 499 A.D.
Hindu and Arabian Period:	500 to 1199
Transition Period:	1200 to 1599
Century of Enlightenment:	1600 to 1699
Modern Period:	1700 to present

We will profile each of these periods in Part I (Chapters 1–6), and then in Part II (Chapters 7–11) we will focus on situations in which you can apply the power of mathematics to your everyday life.

This book was written for people who are math-avoiders, people who think they can't work math problems, and people who think they are never going to use math. Do you see yourself making any of these statements?







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There are many reasons for reading a book, but the best reason is because you want to read it. Although you are probably reading this first section because you were requested to do so by your instructor, it is my hope that in a short while you will be reading this book because you want to read it.

Do you think that you can be reasonably successful in other subjects but are unable to do math? Do you make career choices based on avoidance of mathematics courses? If so, you have *math anxiety.* If you reexamine your negative feelings toward mathematics, you can overcome them. In this book, I'll constantly try to help you overcome these feelings.

Sheila Tobias, an educator, feminist, and founder of an organization called Overcoming Math Anxiety, has become one of our nation's leading spokespersons on math anxiety. She is not a mathematician, and in fact describes herself as a math-avoider. She has written a book titled *Overcoming Math Anxiety* (New York: W. W. Norton & Company, 1978; available in paperback). I recommend this book to anyone who has ever said "I'm no good at numbers." In this book, she describes a situation that characterizes anxiety (p. 45):

> Paranoia comes quickly on the heels of the anxiety attack. "Everyone knows," the victim believes, "that I don't understand this. The teacher knows. Friends know. I'd better not make it worse by asking questions. Then everyone will find out how dumb I really am." This paranoid reaction is particularly disabling because fear of exposure keeps us from constructive action. We feel guilty and ashamed, not only because our minds seem to have deserted us but because we believe that our failure to comprehend this one new idea is proof that we have been "faking math" for years.

The reaction described in this paragraph sets up a vicious cycle. The more we avoid math, the less able we feel; and the less able we feel, the more we avoid it. The cycle can also work in the other direction. What do you like to do? Chances are, if you like it, you do it. The more you do something, the better you become at it. In fact, you've probably thought, "I like to do it, but I don't get to do it as often as I'd like to." This is the normal reaction toward something you like to do. In this book, I attempt to break the negative cycle concerning math and replace it with a positive cycle. However, I will need your help and willingness to try.

The central theme in this book is problem solving. Through problem solving I'll try to dispel your feelings of panic. Once you find that you are capable of doing mathematics, we'll look at some of its foundations and uses. There are no prerequisites for this book; and as we progress through the book, I'll include a review of the math you never quite learned in school—from fractions, decimals, percents, and metrics to algebra and geometry. I hope to answer the questions that, perhaps, you were embarrassed to ask.

I hope you will enjoy reading this book; but if you feel an anxiety attack coming, STOP and put it aside for a while. Talk to your instructor, or call me. My telephone number is

(707) 829-0606

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