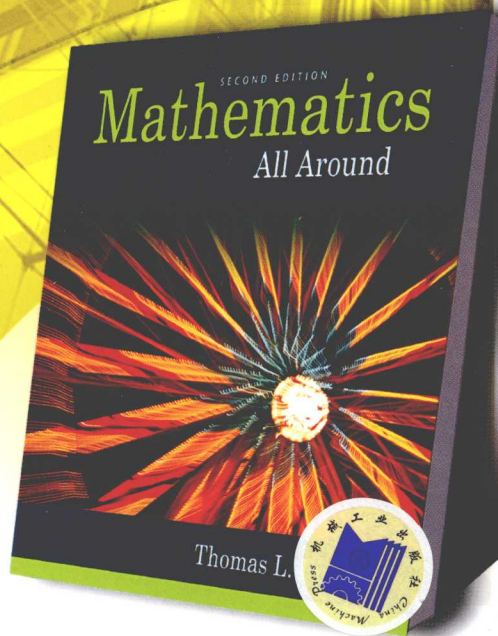


身边的数学

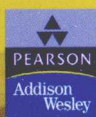
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Mathematics All Around, 2e

(美) Thomas L. Pirnot 著



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时代教育·国外高校优秀教材精选

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引进国外优秀原版教材，在有条件的学校推动开展英语授课或双语教学，自然也引进了先进的教学思想和教学方法，这对提高我国自编教材的水平，加强学生的英语实际应用能力，使我国的高等教育尽快与国际接轨，必将起到积极的推动作用。

为了做好教材的引进工作，机械工业出版社特别成立了由著名专家组成的国外高校优秀教材审定委员会。这些专家对实施双语教学做了深入细致的调查研究，对引进原版教材提出了许多建设性意见，并慎重地对每一本将要引进的原版教材一审再审，精选再精选，确认教材本身的质量水平，以及权威性和先进性，以期所引进的原版教材能适应我国学生的外语水平和学习特点。在引进工作中，审定委员会还结合我国高校教学课程体系的设置和要求，对原版教材的教学思想和方法的先进性、科学性严格把关，同时尽量考虑原版教材的系统性和经济性。

这套教材出版后，我们将根据各高校的双语教学计划，举办原版教材的教师培训，及时地将其推荐给各高校选用。希望高校师生在使用教材后及时反馈意见和建议，使我们更好地为教学改革服务。

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序

由 Thomas L. Pirnot 编著的 Mathematics All Around 一书是为从事社会科学、教育学、商业、艺术和其他非理工类专业的学生而写的教学教科书。本书可以使从事这些专业的学生理解并欣赏到数学在各个领域的许多精彩应用。

本书共 14 章，内容包括集合论、数理逻辑、图论、数论、统计、概率、代数、几何等。全书以数学的应用作为动机，每一章的开始提出实际问题，然后发展必要的数学工具，再解决这些实际问题，在应用中进一步加强对数学的理解。因此提出问题和解决问题占本书很大篇幅。众多应用问题中有些联系日常生活：如信用卡购物问题，分期付款与抵押贷款问题，年利率的计算，运动队成绩的评价，彩票获奖的几率，股票市场中的决策问题，疾病的传播问题，席位的公平分配问题，唱片销售的回归模型等；有些是著名的数学问题：如四色问题，TSP 问题 (Traveling Salesman Problem)；也有些是数学在高新技术中的应用问题：如模糊逻辑用于空调系统，矩阵用于医学计算机成像、图形加速和计算机图形学，分形用于人体中血管、气管的研究，用于创作逼真的自然景观。总之它们使本书变得越味横生。

全书贯穿着强烈的应用意识，使数学理论紧密联系政治、经济、体育、艺术、医学、生物、科技、环境等方面的实际问题，这在国内外数学教科书中是不多见的。本书还从教育学的角度对叙述方式和版面作了精心安排，使得所有概念和理论都由浅入深，因此本书在阅读时易读易懂。为了引导学生掌握正确的学习方法，作者还在第一章的第一节讨论了解决实际数学应用问题的策略和原则，并提供用以下方式来解决数学问题：1. 画图；2. 用自己的语言叙述问题；3. 理清问题的条理；4. 找规律；5. 简化问题；6. 猜想；7. 将新问题变为老问题。

本书除了可作为社会科学、教育学、商业、艺术等文科专业的教材以外，还可以作为理工类学生、教师、工程技术人员和管理工作者的参考书或工具书。

北京工商大学
章栋恩

Preface

I have written *Mathematics All Around* based on the belief that there are three things a student must focus on in order to learn and remember mathematics — understanding, understanding, understanding! Instead of simply presenting the students with an equation or method and asking them to repeat the procedure, I explain the thinking behind the subject so they have a better grasp of the material and an easier time with the work. With this approach, we can discuss topics usually considered “too difficult” for liberal arts students such as fuzzy logic and dynamical systems. As a result, students end up with an understanding of and a positive attitude toward many different and often challenging mathematical topics.

I, and many other instructors who have used the first edition, have found that students respond enthusiastically to the realistic, modern applications presented in this text. I believe that the students who use this book will become more educated consumers of the vast amount of technical and mathematical information that they encounter daily. I also want to present to them some of the most interesting and exciting ideas of mathematics at a level accessible to all students.

Some of the topics from this text that students have enjoyed are:

- Using **fuzzy logic** in complex decision making
- Using **dynamical systems** to explore antibiotics in the bloodstream and the twentieth-century arms race
- Organizing large projects by using **directed graphs**
- Understanding the role mathematics plays in the politics of **voting and apportionment**
- Using mathematics to help them make better **financial decisions** involving loans, credit cards, mortgages, and annuities
- Understanding how **counting and probability** theory can explain lotteries, gambling, and the genetics of inherited diseases
- Using linear, quadratic, exponential, and logistic equations for **modeling** realistic situations such as the ups and downs of presidential popularity polls and the growth of epidemics while appreciating the appropriateness, strengths, and most importantly, the weaknesses of these models
- Seeing how **geometry** is used to solve practical everyday problems and understanding how **fractal geometry** can pattern the way blood vessels and air passageways are arranged in the human body and how it can be used to create realistic, computer-generated, natural scenes
- Understanding how to use **statistics** to understand and compare data and also learning how to write a warranty that will almost always run out before the product breaks down.

As with the first edition, I have written the second edition to provide students majoring in the liberal arts, the social sciences, education, business, and other nonscientific areas an understanding and appreciation of mathematics and its many fascinating applications. This book is particularly appropriate for students who need to satisfy a one- or two-course requirement in mathematics for graduation or to transfer to another institution.

In this second edition, I have responded to the advice of reviewers and previous users by expanding the content (as described below), refining the presentations of some material to make it easier to teach and learn, and enlarging the exercise sets to allow students more opportunity to practice their newly learned skills. Additionally, I have incorporated their suggestions regarding communicating mathematics and using technology throughout the book via the exercises and Web site.

New Content

I have added three chapters to this text:

- *Numeration Systems* (Chapter 4)—Includes a discussion of modular arithmetic and secret codes
- *Number Theory and the Real Number System* (Chapter 5)—Includes sections on exponents and scientific notation and sequences
- *Modeling with Systems of Linear Equations and Inequalities* (Chapter 7)—Includes a section on linear programming and its applications

Additionally, I have added sections to the following chapters:

- Chapter 1, *Set Theory*, now contains a new section on estimation (1.2).
- Chapter 2, *Logic*, has a new section on inductive and deductive reasoning (2.1).
- Chapter 6, *Algebraic Models*, has a section dealing with proportion and variation (6.5).
- Chapter 8, *Geometry*, now contains a section on the metric system and dimensional analysis (8.5).
- Chapter 9, *Apportionment*, has been streamlined and I have added a new section discussing Jefferson's, Adams', and Webster's apportionment methods (9.4).
- Chapter 14, *Descriptive Statistics*, now includes a brief discussion of gathering reliable data (14.1).

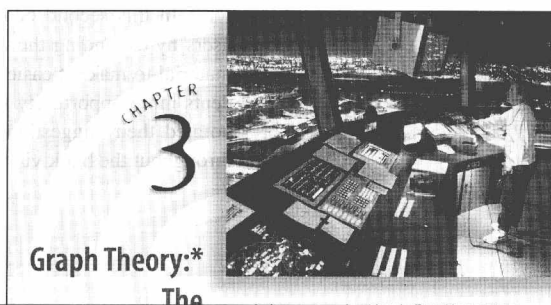
We have deleted the chapter on matrices, which included a section on matrix representations of geometrical transformations and computer graphics. However, those who still wish to use this material can download it in its entirety from the book's Web site, www.aw.com/pirnot.

Pedagogical Features

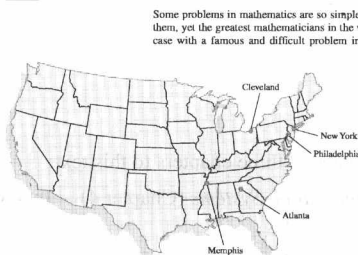
The many strong pedagogical features of Mathematics All Around will make this text a useful tool for the student.

Motivation with Emphasis on Applications

Applications throughout the text motivate the discussion of the mathematics and increase the student's interest in the material. In addition, each chapter opener emphasizes realistic problem situations and gives a broad overview of the chapter material. Toward the end of this brief section, I frequently present problems to motivate the mathematics we will be discussing. After developing the necessary mathematical tools, I return to solve the problem, reinforcing the value of the concepts studied in the chapter.



3.2 THE TRAVELING SALESPERSON PROBLEM



Some problems in mathematics are so simple to state that a child can understand them, yet the greatest mathematicians in the world cannot solve them. This is the case with a famous and difficult problem in graph theory called the traveling salesperson problem (TSP). The TSP gets its name from the problem of determining the most efficient way for a salesperson to schedule a trip to a series of cities and then return home.

For an example of a TSP, suppose that Danielle, who is regional sales manager for a publishing company, lives in Philadelphia and must make visits next week to branch offices in New York City, Cleveland, Atlanta, and Memphis (see Figure 3.21). In order to determine which would be her cheapest trip, she has obtained prices of flights between each pair of

branch offices wishes to minimize
re airport, air traffic controllers
to get passengers to their destina-
the tribal alliances among
works administrator in Buffalo,
to locate the most efficient routes
congressional subcommittee
who exerts the greatest influence.
related, each of these people is
jects to each other. The sales man-
between cities in terms of the cost
ffalo administrator has to know
nected by streets. The political
committee members are.

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Problem Solving, expanded

Problem solving is one of the main themes of this text. Section 1.1 discusses strategies and principles that help the student understand and attack problems more effectively. In this section I introduce the Three-Way Principle, which encourages students to approach mathematical ideas graphically, verbally, and by constructing examples. I return to these discussions frequently, via the **Problem Solving** boxes, thereby making problem solving an integrated component of each chapter. Remarks titled **Some Good Advice** point out common mistakes, provide further advice on problem solving, and make connections between different areas of mathematics. Some Good Advice includes learning not to use *equal* and *equivalent* interchangeably or learning that in logic, the form of a statement is more important than its literary style. I have increased the number of **Problem Solving** and **Some Good Advice** boxes in this edition.

The Three-Way Principle

We conclude this section with a method for approaching mathematical concepts that we illustrate in Figure 1.4.

Whether you are learning a new concept or trying to gain insight into a problem, it is helpful to use the ideas we have discussed in this chapter to approach mathematical situations in three ways.

- **Verbally**—Make analogies. State the problem in your own words. Compare it with situations you have seen in other areas of mathematics.
- **Graphically**—Draw a graph. Draw a diagram.
- **By example**—Make numerical or other kinds of examples to illustrate the situation.

Not every one of these three approaches fits every situation. However, if you get in the habit of using a verbal-graphical-example approach to doing

PROBLEM SOLVING

In deciding whether a set property holds, use the Three-Way Principle from Section 1.1. Recall that you can understand an idea:

- Verbally—Make analogies or try to describe the situation verbally.
- Graphically—Draw Venn diagrams.

SOME GOOD ADVICE

When you use logic to rewrite a statement, the result can sound awkward. You may wish to smooth out the grammar so that the sentence sounds better. This is usually a mistake! Unless you are quite careful, you can easily change the meaning of a sentence by rewriting it. In logic, the form of a statement is more important than its literary style.

pages 12, 45, 96

Format

The format makes this text easy to use and makes learning mathematics easier for the student. I introduce ideas conversationally and then illustrate them with clear, simple examples. Summary boxes help students locate information when doing exercises. After reinforcing highlighted points with more examples, students test their understanding by taking a **Quiz Yourself**. More detailed examples occur later in a section after the ideas have been clearly discussed.

Quiz Yourself 8

According to a recent census, Iowa had a population of approximately 2.8 million people and six representatives to the U.S. House of Representatives; and Nebraska had a population of 1.6 million people and 3 representatives. Use the Huntington–Villapartitioning principle to determine which state is most deserving of an additional representative.

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Historical Highlight: Hypatia

Throughout the history of mathematics, fewer women than men are mentioned for their contributions because traditionally women were discouraged from studying mathematics. One notable exception is Hypatia, who was born in Greece in 370 A.D. Her father, who was a professor of mathematics at the University of Alexandria, gave her a classical education, which included mathematics. She lectured on both philosophy and mathematics at Alexandria and wrote major papers on geometry, including the work of Eu-

clid. She also did work in philosophy and astronomy and is believed to have invented several astronomical devices.

Unfortunately, her work in science caused her problems with the Christian church and, moreover, as a Greek she was seen as a pagan. In 415 a mob attacked and brutally murdered her, which caused other scholars to flee Alexandria. This tragic event marked the end of the golden age of Greek mathematics and, some feel, the beginning of the Dark Ages in Europe.

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Quiz Yourself, expanded

Each section contains numerous short quizzes called “Quiz Yourself,” which students can use to check their understanding of the material immediately preceding the quiz. These quizzes can be used as a break in the flow of the lecture material and to encourage student participation. The number of **Quiz Yourself** exercises has been increased.

Highlights, expanded

Each chapter contains **Highlight** boxes that discuss the history and applications of the topics being presented. These highlights help students understand the material that they are learning in a broader context. There are more highlights, particularly those titled **Historical Highlights**. A listing of the historical figures mentioned in the text is located in the inside of the front cover and includes individuals such as Aristotle, George Polya, Sophie Germain, and Georg Cantor.

Using Technology, expanded

Also in the **Highlight** boxes, I encourage students to take advantage of available technology. I explain how tools such as spreadsheets, graphing calculators, and computer algebra systems can be used effectively to solve problems. Although I encourage the students to use these technologies, I have purposely not made technology a requirement for this book. Throughout the text, I make frequent references to the technology section of the Web site mentioned earlier. There the instructor and student can download tutorials and examples using spreadsheets, graphing calculators, and computer algebra systems.

The Hamilton method uses fractional parts to apportion representatives.

If we give each company its integer part as its number of board members, then Naxxon will have four members, Aruco will have three, and Eurofile will have one. Thus there will be only eight members on the board. In order to have the required nine, we must now decide which company gets the additional member. It seems reasonable to assign the member to Eurofile, which has the highest fractional part—namely 0.44. In fact, this is exactly how the **Hamilton apportionment method*** would allocate the last board member.

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Topic Statements

Topic statements divide each section into subsections to provide students with a useful outline of the chapter’s material as well as providing a clear idea of the concept being discussed.

Exercises, expanded

In general, the exercise sets begin with straightforward problems that closely follow the examples and **Quiz Yourself** questions. In addition to these problems, other exercises require the student to think critically about extensions of ideas. Many exercises are application oriented, using real data. More challenging and open-ended exercises are placed in a section labeled **Further Exercises**.

Many of the exercise sets have been greatly expanded. We also have labeled numerous exercises **Communicating Mathematics**, which ask the student to write about the mathematics he or she is studying. We have also indicated a number of exercises (their numbers are circled in red) that can be used as **Group Exercises**.

Summary and Chapter Test

Each chapter has a summary followed by a chapter test. Chapter test questions are cross-referenced to the sections that cover the points being tested. This enables a student who is not comfortable with a particular concept to return to the section covering that material.

Of Further Interest

Brief sections called **Of Further Interest** introduce subjects that go beyond the main chapter material but are of interest for students. The section "The Annual Percentage Rate" in the consumer mathematics chapter illustrates this intent. Because the **Of Further Interest** section appears at the end of the chapter, it can be treated as a bonus topic or easily omitted at the instructor's discretion.

Of Further Interest

FUZZY LOGIC

To say "It is warm today" may not mean the same thing on the first day of March as it does in the middle of August. Statements we make in everyday life have shades of meaning and, in that sense, differ from the statements that we have been studying in symbolic logic. Although it may be warm today, perhaps it is not as warm as it was two weeks ago. To simply say "It is warm today" ignores exactly how warm it is. The strict condition that statements must be either true or false makes symbolic logic unsuitable for representing many real-life situations.

Statements in fuzzy logic have truth values between 0 and 1.

In order to apply the techniques of logic more widely, mathematicians developed *fuzzy logic*. This term might seem contradictory, but, as you will see shortly, it is a perfectly acceptable, well-developed area of mathematics. Once we define the meaning of fuzzy statements, and explain how fuzzy connectives behave, we can work with them as we did for other (nonfuzzy*) statements.

DEFINITIONS

In *fuzzy logic*, a **statement** is a declarative sentence that has an associated **truth value** between 0 and 1 inclusive.

EXAMPLE 1 The Truth Values of Statements in Fuzzy Logic

Here are some examples of statements in *fuzzy logic*.



- "I like peach ice cream," with a truth value of 0.9.
- "Tiger Woods is a great golfer," with a truth value of 0.92.
- "Maine is a large state," with a truth value of 0.45.
- "*Gone with the Wind* is a great movie," with a truth value of 0.73.
- "You find mathematics interesting," with a truth value of 0.7.

The way we assigned truth values in Example 1 is somewhat arbitrary. You may want to assign a truth value of 0.85 to the statement "*Gone with the Wind* is a great movie" because you feel that it is a greater movie than we do. *This is perfectly OK and is really the point of fuzzy*

* Some use the term *crisp statements* to describe the statements we studied earlier.

Acknowledgments

Again, I would like to acknowledge the wonderfully talented team at Addison Wesley who produced this edition. I thank my senior acquisitions editor Anne Kelly and my project editor Rachel S. Reeve for their sound advice and generous encouragement throughout this project. I appreciate the work of Peggy McMahon who supervised the production of the text and also thank Barbara Atkinson, senior designer, for her beautiful design.

I also would like to thank Heidi Howard, who wrote the solutions manuals, corrected my errors, and suggested many improvements for the exercises in this edition. I appreciate the care that Kelly Carey and Cathy Ferrer took in checking for accuracy in the text and the exercise answers. Jaime Bailey and Joanne Ha contributed in so many ways in producing this second edition. Emily Hui updated the data and examples from the first edition and I thank her for her careful work. Our marketing manager Becky Anderson and Julia Coen have helped greatly in spreading the message of *Mathematics All Around*. Sara Anderson has produced an excellent Web site as well as the fine material for the MyMath-Lab supplement that accompanies this book.

I also appreciate Greg Tobin's continuing confidence and support for this project.

I would particularly like to thank my wife Ann and children, Matt, Tony, Joanna, and Mike who supported me and encouraged me throughout this project.

Finally, I would like to thank the reviewers and the previous users who helped me to reshape *Mathematics All Around* into a better text. Again, I have listened carefully to you and this edition would not be what it is today without your thoughtful advice and your many constructive suggestions. The following is a list of reviewers of the first and second editions (reviewers of the second edition are marked with an “*”).

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*Seth Armstrong	Southern Utah University
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