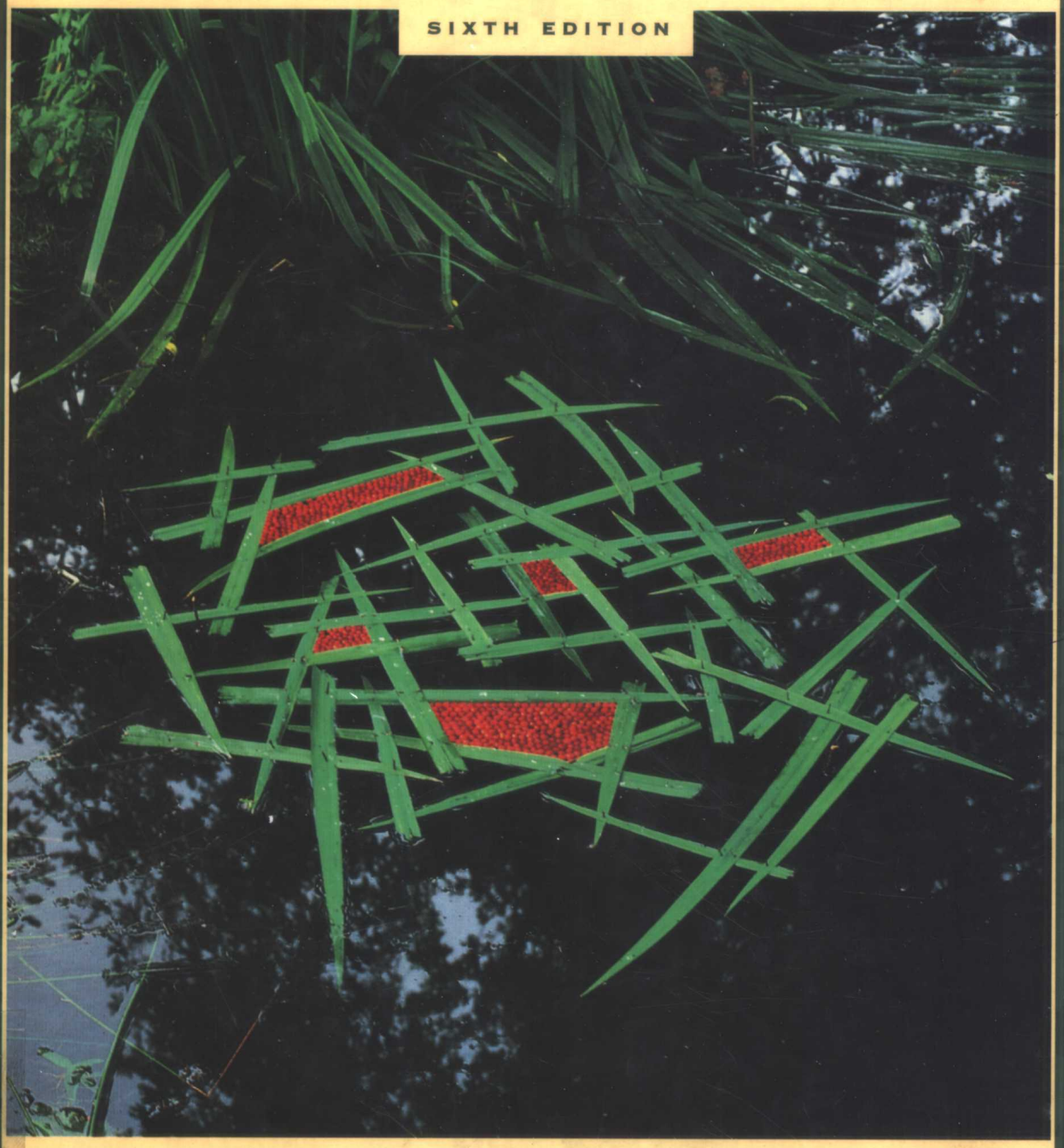
FINITE MATHEMATICS

SIXTH EDITION



LIAL • GREENWELL • MILLER

Finite Mathematics

SIXTH EDITION

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Finite Mathematics

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Preface

Finite Mathematics is a solid, application-oriented text for students majoring in business, management, economics, or the life or social sciences. A prerequisite of two to three semesters of high school algebra is assumed. Many new features, including new exercises, new applications, and increased use of the graphing calculator, make this latest edition easier to understand and more enjoyable.

New and Enhanced Features

Increased Use of Graphing Calculators Although students reading this book do not need a graphing calculator, using one will enhance their learning. The number of exercises requiring use of a graphing calculator has been increased since the fifth edition. These exercises are now distributed throughout the exercise sets as appropriate and are labeled with the  icon. For example, see pages 78, 79, and 218. Furthermore, graphing calculators are discussed throughout the text whenever they help clarify a topic. We have used the TI-83 for our examples and screen shots, but students can succeed in the course with any appropriate graphing calculator.

Increased Use of Referenced Real-Data Applications Many new application exercises and examples use real data and are based on articles appearing in newspapers, books, and journals. For example, see pages 114, 118, and 201.

Comparative Entrance Exam Questions To give students an idea of international standards in mathematics education, we have added problems from entrance examinations for Japanese universities. We continue to offer exercises from actuarial or CPA exams, enabling students to see how the mathematics introduced in the book is used by professionals in these fields. See pages 142, 223, and 345.

Increased Extended Applications As in previous editions, we have included in-depth applied exercises (labeled "Extended Applications") at the end of most chapters to stimulate student interest and for use as group projects. We have written new Extended Applications for this edition and supplied a larger collection of them in the *Instructor's Resource Guide and Solutions Manual*. See pages 52–54 and 120.

Increased Writing, Conceptual, and Connection Exercises We have built upon these popular features of the previous edition by adding new exercises that strengthen conceptual understanding or that require the student to respond by writing a few sentences. We have also included more connection exercises (labeled with the ↻ icon) that integrate topics presented in different sections or chapters. See pages 294 and 344.

Continuing Features

This edition continues to offer the many popular features of the previous edition:

- applied exercises (labeled "Applications") that are grouped by subject, with subheadings indicating what the problem is about;
- fully developed examples with explanatory comments in color on the side;
- careful explanation of the mathematics;
- exercises arranged according to the material in the section, with the more challenging exercises placed near the end;
- thought-provoking questions that open most sections, which are answered in an application within the section or in the exercises for the section;
- margin reviews giving short explanations or comments reminding students of skills or techniques learned earlier that are needed at this point;
- common student difficulties and errors highlighted under the heading "Caution";
- important treatments and asides highlighted with the heading "Note";
- an algebra reference, designed to be used either in class or by individual students;
- an index of applications showing the abundant variety used in the text and allowing direct reference to particular topics; and
- summaries of rules or formulas for chapters where students may have trouble deciding which of several techniques to use.

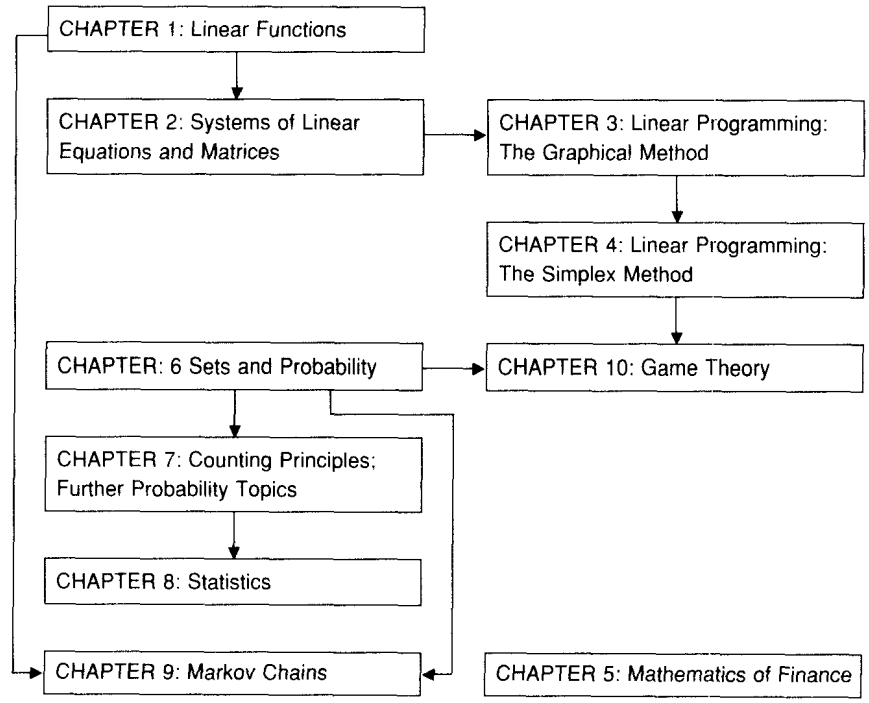
Key Content Changes

The sixth edition preserves the basic format and order of topics of the previous edition. A few changes were made, however.

- An algebra reference chapter (Chapter R) was added to the beginning of the book.
- The chapter on Linear Functions (Chapter 1) is more concise, bringing the concepts of slope and linear equations to the beginning of the chapter.
- The chapter on Mathematics of Finance (Chapter 5) appears earlier in the text, after the chapters on linear programming (Chapters 3 and 4).
- The section on Simple Interest has been condensed and combined with the section on compound interest (Section 5.1).

- Some of the material in the chapters on Further Probability Topics and Statistics (Chapters 7 and 8) was rearranged to emphasize more clearly the distinctions and the similarities between probability and statistics.
- The chapter on Game Theory (Chapter 10) was made more concise by introducing the key concept of strategy in the first section.

The following is a chart of chapter prerequisites. As shown, the course could begin with either Chapter 1 or Chapter 6, and Chapter 5 on the mathematics of finance could be covered at any time.



Supplements

For the Instructor The *Instructor's Resource Guide and Solutions Manual* (ISBN 0-321-40733-4) contains solutions to even-numbered exercises; a multiple-choice version and a short-answer version of a pretest and final exam, with answers; at least 100 extra test questions per chapter, with answers; a set of hints for teaching; a list of conceptual, writing, and challenging exercises; and additional Extended Applications.

The *Answer Book* (ISBN 0-321-40734-2) provides answers to every exercise in the text, including the Extended Applications.

TestGen EQ is a computerized test generator that allows instructors to select test questions by objective or section. The software is algorithm driven so that regenerated number values maintain problem types and provide many test items in both multiple-choice and open-response formats for one or more test forms. The editor allows instructors to modify existing questions or to create their own including graphics and accurate math symbols. Tests created with TestGen EQ can be used with *QuizMaster*, which records student scores on a single computer or network as they take tests, and prints reports for students, classes, or courses. TestGen EQ and QuizMaster are available in Windows and Macintosh formats.

A supplementary chapter entitled *Digraphs and Networks* is available to you and your students at no charge should you desire to cover these topics.

For the Student The *Student's Solutions Manual* (ISBN 0-321-01625-4) provides solutions to odd-numbered exercises and sample chapter tests with answers.

The Graphing Calculator Manual for Finite Mathematics and Calculus with Applications (ISBN 0-321-02138-X) provides detailed information on using some of the more popular graphing calculators to study topics in the text, plus listings of some programs for graphing calculators.

Further information on the text, as well as TI-83 programs that can be downloaded to a computer (and transferred to a TI-83 calculator using TI-Graph Link) are available at the following Internet site: http://www.FiniteZone.com.

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Margaret L. Lial
Raymond N. Greenwell

Index of Applications

Business & Economics

General Interest

Life Sciences

Physical Sciences

Social Sciences

CHAPTER R

Algebra Reference

The word *algebra* is derived from the Arabic word *al-jabr*, which appeared in the title of a book by Arab mathematician al-Khowarizmi in the early ninth century A.D. The study of algebra in modern times has grown to include many abstract ideas, but in this text we will be concerned primarily with the topics of elementary algebra found in al-Khowarizmi's book.

This algebra reference is designed for self-study; you can study it all at once or refer to it when needed throughout the course. Since this is a review, answers to all exercises are given in the answer section at the back of the book.

R.1 Polynomials

An expression such as $9p^4$ is a **term;** the number 9 is the **coefficient,** p is the **variable,** and 4 is the **exponent.** The expression p^4 means $p \cdot p \cdot p \cdot p$, while p^2 means $p \cdot p$, and so on. Terms having the same variable and the same exponent, such as $9x^4$ and $-3x^4$, are **like terms.** Terms that do not have both the same variable and the same exponent, such as m^2 and m^4, are **unlike terms.**

A **polynomial** is a term or a finite sum of terms in which all variables have whole number exponents, and no variables appear in denominators. Examples of polynomials include

$$5x^4 + 2x^3 + 6x, \quad 8m^3 + 9m^2n - 6mn^2 + 3n^3, \quad 10p, \quad \text{and} \quad -9.$$

Adding and Subtracting Polynomials The following properties of real numbers are useful for working with polynomials and combining like terms.

PROPERTIES OF REAL NUMBERS

For all real numbers a, b, and c,

1. $a + b = b + a$; $ab = ba$; **Commutative properties**
2. $(a + b) + c = a + (b + c)$; $(ab)c = a(bc)$; **Associative properties**
3. $a(b + c) = ab + ac$. **Distributive property**

EXAMPLE 1

(a) $2 + x = x + 2$ Commutative property of addition

(b) $x \cdot 3 = 3x$ Commutative property of multiplication

(c) $(7x)x = 7(x \cdot x) = 7x^2$ Associative property of multiplication

(d) $3(x + 4) = 3x + 12$ Distributive property ■

The distributive property can be used to add or subtract polynomials. Only like terms may be added or subtracted. For example,

$$12y^4 + 6y^4 = (12 + 6)y^4 = 18y^4,$$

and

$$-2m^2 + 8m^2 = (-2 + 8)m^2 = 6m^2.$$

but the polynomial $8y^4 + 2y^5$ cannot be further simplified. To subtract polynomials, use the fact that $-(a + b) = -a - b$. In the next example, we show how to add and subtract polynomials.

EXAMPLE 2 Add or subtract as indicated.

(a) $(8x^3 - 4x^2 + 6x) + (3x^3 + 5x^2 - 9x + 8)$

Combine like terms.

$$\begin{aligned}(8x^3 - 4x^2 + 6x) + (3x^3 + 5x^2 - 9x + 8) &= (8x^3 + 3x^3) + (-4x^2 + 5x^2) + (6x - 9x) + 8 \\ &= 11x^3 + x^2 - 3x + 8\end{aligned}$$

(b) $(-4x^4 + 6x^3 - 9x^2 - 12) + (-3x^3 + 8x^2 - 11x + 7)$

$$= -4x^4 + 3x^3 - x^2 - 11x - 5$$

(c) $(2x^2 - 11x + 8) - (7x^2 - 6x + 2)$

$$\begin{aligned}&= (2x^2 - 11x + 8) + (-7x^2 + 6x - 2) \\ &= -5x^2 - 5x + 6\end{aligned}$$

■

Multiplying Polynomials The distributive property is used also when multiplying polynomials, as shown in the next example.

EXAMPLE 3 Multiply.

(a) $8x(6x - 4)$

$$\begin{aligned}8x(6x - 4) &= 8x(\mathbf{6}x) - 8x(\mathbf{4}) \\ &= 48x^2 - 32x\end{aligned}$$

(b) $(3p - 2)(p^2 + 5p - 1)$

$$\begin{aligned}&(3p - 2)(p^2 + 5p - 1) \\ &\quad = 3p(p^2) + 3p(\mathbf{5}p) + 3p(\mathbf{-1}) - 2(p^2) - 2(\mathbf{5}p) - 2(\mathbf{-1}) \\ &\quad = 3p^3 + 15p^2 - 3p - 2p^2 - 10p + 2 \\ &\quad = 3p^3 + 13p^2 - 13p + 2\end{aligned}$$

(c) $(x + 2)(x + 3)(x - 4)$

$$\begin{aligned}&(x + 2)(x + 3)(x - 4) \\ &\quad = [(x + 2)(x + 3)](x - 4) \\ &\quad = (x^2 + 2x + 3x + 6)(x - 4) \\ &\quad = (x^2 + 5x + 6)(x - 4) \\ &\quad = x^3 + 5x^2 + 6x - 4x^2 - 20x - 24 \\ &\quad = x^3 + x^2 - 14x - 24\end{aligned}$$

■

A **binomial** is a polynomial with exactly two terms, such as $2x + 1$ or $m + n$. When two binomials are multiplied, the FOIL method (First, Outer, Inner, Last) is used as a shortcut. This method is shown in the next examples.

EXAMPLE 4 Find $(2m - 5)(m + 4)$ using the FOIL method.

$$\begin{aligned}(2m - 5)(m + 4) &= \overset{\text{F}}{(2m)(m)} + \overset{\text{O}}{(2m)(4)} + \overset{\text{I}}{(-5)(m)} + \overset{\text{L}}{(-5)(4)} \\ &= 2m^2 + 8m - 5m - 20 \\ &= 2m^2 + 3m - 20\end{aligned}$$

■

EXAMPLE 5 Find $(2k - 5)^2$.

Use FOIL.

$$\begin{aligned}(2k - 5)^2 &= (2k - 5)(2k - 5) \\ &= 4k^2 - 10k - 10k + 25 \\ &= 4k^2 - 20k + 25\end{aligned}$$

Notice that the product of the square of a binomial is the square of the first term, $(2k)^2$, plus twice the product of the two terms, $(2)(2k)(-5)$, plus the square of the last term, $(-5)^2$. ■

Caution Avoid the common error of writing $(x + y)^2 = x^2 + y^2$. As Example 5 shows, the square of a binomial has three terms, so

$$(x + y)^2 = x^2 + 2xy + y^2.$$

Furthermore, higher powers of a binomial also result in more than two terms. For example, verify by multiplication that

$$(x + y)^3 = x^3 + 3x^2y + 3xy^2 + y^3.$$

R.1 Exercises

Perform the indicated operations.

1. $(2x^2 - 6x + 11) + (-3x^2 + 7x - 2)$
2. $(-4y^2 - 3y + 8) - (2y^2 - 6y - 2)$
3. $-3(4q^2 - 3q + 2) + 2(-q^2 + q - 4)$
4. $2(3r^2 + 4r + 2) - 3(-r^2 + 4r - 5)$
5. $(.613x^2 - 4.215x + .892) - .47(2x^2 - 3x + 5)$
6. $.83(5r^2 - 2r + 7) - (7.12r^2 + 6.423r - 2)$
7. $-9m(2m^2 + 3m - 1)$
8. $(6k - 1)(2k - 3)$
9. $(5r - 3s)(5r + 4s)$
10. $(9k + q)(2k - q)$
11. $\left(\frac{2}{5}y + \frac{1}{8}z\right)\left(\frac{3}{5}y + \frac{1}{2}z\right)$
12. $\left(\frac{3}{4}r - \frac{2}{3}s\right)\left(\frac{5}{4}r + \frac{1}{3}s\right)$
13. $(12x - 1)(12x + 1)$
14. $(6m + 5)(6m - 5)$
15. $(3p - 1)(9p^2 + 3p + 1)$
16. $(2p - 1)(3p^2 - 4p + 5)$
17. $(2m + 1)(4m^2 - 2m + 1)$
18. $(k + 2)(12k^3 - 3k^2 + k + 1)$
19. $(m - n + k)(m + 2n - 3k)$
20. $(r - 3s + t)(2r - s + t)$
21. $(x + 1)(x + 2)(x + 3)$
22. $(x - 1)(x + 2)(x - 3)$