

# COLLEGE ALGEBRA

through Modeling and Visualization



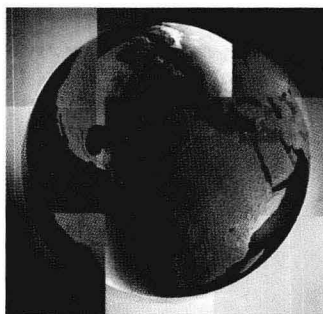
Gary Rockswold

SECOND EDITION

# COLLEGE ALGEBRA

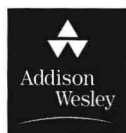
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SECOND EDITION



Gary K. Rockswold

*Minnesota State University, Mankato*



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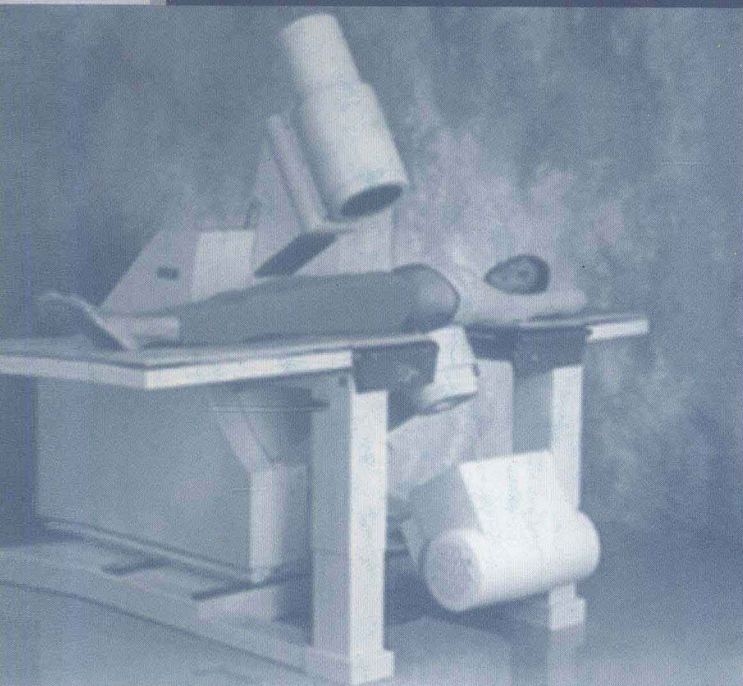
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# How Mathematics Is Used



## MEDICINE

A lithotripter is a machine designed to break up kidney stones, without surgery, by producing powerful shock waves. To accurately focus these shock waves, a lithotripter uses the reflective property of ellipses. This is just one of the many applications involving ellipses and other types of conic sections, which are found in analytic geometry.

## BUSINESS AND SOCIAL SCIENCES

Linear programming, which involves systems of linear inequalities, is an algorithm used to optimize quantities such as cost, profit, and inventories. It was developed during World War II as a method of efficiently allocating supplies. Linear programming applications frequently contain thousands of variables, requiring the use of computers.



## DIGITAL SIGNAL PROCESSING

The FCC has mandated all television stations to submit digital signals by the year 2006. Digital photography is a new technology in which matrix algebra plays an important role. For example, the image in a black and white photograph is broken up into dots, or pixels, to which each pixel is assigned a shade of gray according to a numbered gray scale. The different shades of gray are stored as numbers in a matrix. Thus, the matrix is a numerical or digital representation of the photograph, which can be stored and transmitted electronically.



*In this technological twenty-first century, mathematics is everywhere. Throughout this book the author discusses how mathematics is used in various fields. Here are some examples of the many applications you will encounter.*

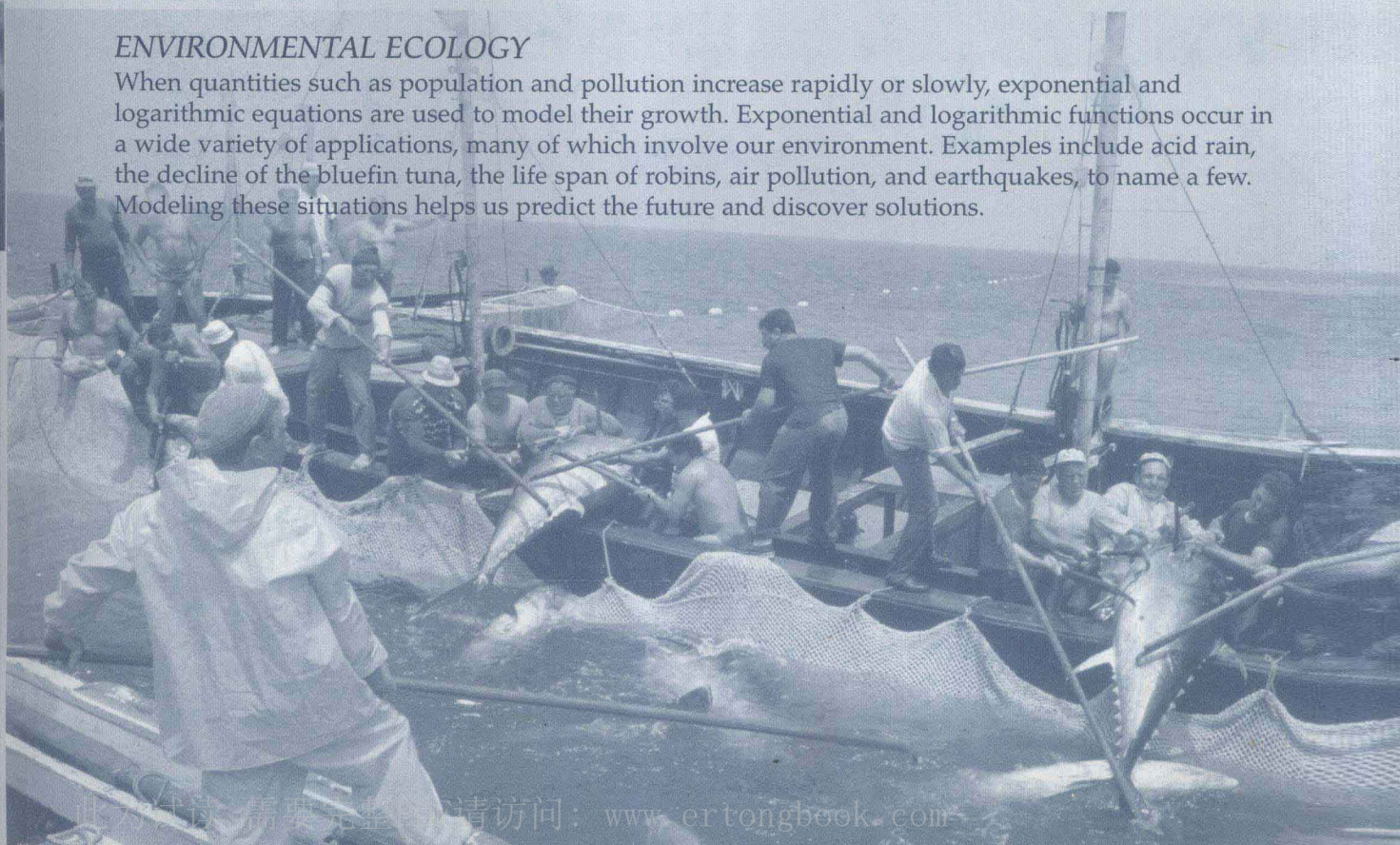
### COMPUTER GRAPHICS

Dynamically displayed data, which involves translations of graphs and figures, play an important role in computer graphics. In early motion pictures, it was common to have the background move to create the appearance that the actors were moving. This same technique is used today on two-dimensional graphics. For example, in video games the background often is translated (shifted in a parallel direction) to give the illusion that the player in the game is moving.



### ENVIRONMENTAL ECOLOGY

When quantities such as population and pollution increase rapidly or slowly, exponential and logarithmic equations are used to model their growth. Exponential and logarithmic functions occur in a wide variety of applications, many of which involve our environment. Examples include acid rain, the decline of the bluefin tuna, the life span of robins, air pollution, and earthquakes, to name a few. Modeling these situations helps us predict the future and discover solutions.

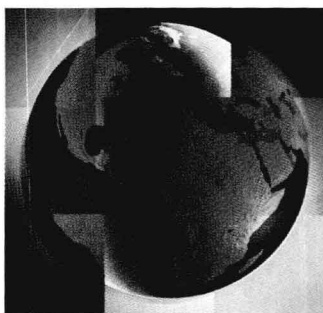




# COLLEGE ALGEBRA

through Modeling and Visualization

SECOND EDITION



# Preface

*College Algebra through Modeling and Visualization* offers an innovative approach that consistently links mathematical concepts to real-world applications by moving from the concrete to the abstract. It demonstrates the relevance of mathematics and answers the question, “When will I ever need to know this?” This text provides a comprehensive curriculum with the balance and flexibility necessary for today’s college algebra courses. The early introduction of functions and graphs allows the instructor to use applications and visualization to present mathematical topics. Real data, graphs, and tables play an important role in the course, giving meaning to the numbers and equations that students encounter. This approach increases students’ interest and motivation, and the likelihood for success.

## APPROACH

The concept of a function is the unifying theme of the text. Functions and their graphs are frequently used to model data, and students are often asked to interpret their results. Mathematical skill building also plays an important role. Instructors are free to strike their own balance of skills, rule of four, applications, modeling, and technology. With a flexible approach to the rule of four (verbal, graphical, numerical, and symbolic methods), instructors can easily emphasize one rule more than another to meet their students’ needs. This approach also extends to modeling, applications, and use of a graphing calculator. The use of technology, which helps students visualize mathematical concepts, is flexible throughout the text, though technology use is not a requirement for students to benefit from this applications-based book. The text contains numerous applications, including models of real-world data with functions and problem-solving strategies. It is not necessary for an instructor to discuss any particular application; rather an instructor has the option to choose from a wide variety of topics.

## CHANGES TO THE SECOND EDITION

The second edition contains several important changes, which are a result of the many comments and suggestions received from instructors, students, and reviewers. The second edition is reorganized into eight chapters rather than six. Both the breadth and depth of the discussions of several topics has increased, and hundreds of new examples and exercises that involve mathematical skill building, applications, and modeling have been included. Examples have been added for students to refer to when doing their homework assignments. Many of the real-data applications from the first edition have been updated to make the data current and relevant to students. The book’s new organization and seamless presentation facilitate students’ understanding of each topic. The extensive exercise sets cover a diverse assortment of topics, and they are carefully graded with several levels of difficulty. The presentation and exercise sets provide instructors with the ability to enhance their courses in several fashions. The chapter summaries have been expanded and presented in an easy-to-read grid.

### • Chapter 1: Introduction to Functions and Graphs

This chapter has been streamlined from six sections to four. A basic introduction to

problem solving is presented in Section 1.1 and the distance formula is now given in Section 1.2. Functions and their representation are introduced in Section 1.3, providing the background necessary for future chapters. The material on quadratic functions and transformations of graphs now appears in Chapter 3. Discussion of increasing and decreasing functions is delayed until Chapter 4.

- **Chapter 2: Linear Functions and Equations**

Section 2.1 is a new section that discusses linear functions and models in detail. Slope is discussed extensively as a rate of change. Equations of lines are now presented before linear equations and inequalities. There is an increased emphasis on problem solving, which now includes several classic word problems. An extensive discussion of piecewise linear functions, including absolute value equations and inequalities, is provided in Section 2.5. Linear regression is introduced in Section 2.6.

- **Chapter 3: Quadratic Functions and Equations**

This new chapter allows an instructor to introduce quadratic functions and equations before covering the more involved nonlinear functions and equations in Chapter 4. Increased emphasis has been given to problem solving. Quadratic equations and inequalities have been separated into two sections. Transformations of graphs are introduced in Section 3.4.

- **Chapter 4: Nonlinear Functions and Equations**

In this chapter, the graphs, zeros, and factorization of polynomials are discussed. Section 4.4 has been reorganized so that instructors are able to cover complex numbers and complex solutions to quadratic equations without covering the fundamental theorem of algebra. More opportunities for modeling with nonlinear functions are provided. Section 4.6, Polynomial and Rational Inequalities, and Section 4.7, Power Functions and Radical Equations, can be omitted, but they do provide opportunities for students to study other nonlinear functions, equations, and inequalities.

- **Chapter 5: Exponential and Logarithmic Functions**

Operations on functions and inverse functions are introduced in Sections 5.1 and 5.2. Section 5.3, Exponential Functions and Models, includes more discussion on the differences between exponential growth and other types of growth. More opportunities for modeling real data with exponential and logarithmic functions are provided throughout the chapter. Logarithmic functions and properties of logarithms are now separated into two sections to provide students with more opportunities to increase skills and work with models. Section 5.7, Constructing Nonlinear Models, is a new section based on nonlinear regression.

- **Chapter 6: Systems of Equations and Inequalities**

This chapter now provides more examples and exercises for students to practice the skills needed to solve systems of linear and nonlinear equations. The material on linear programming has been increased.

- **Chapter 7: Conic Sections**

This new chapter has expanded the material on conic sections from one section to three, thereby providing a more comprehensive discussion with additional exercises. More practice solving nonlinear equations has also been included.

- **Chapter 8: Further Topics in Algebra**

This chapter covers sequences, series, counting, probability, and the binomial theorem. Examples and exercises have been added throughout the chapter. The binomial theorem is presented in its own section. Additional material has been added to Section 8.5, Probability, which includes conditional probability and dependent events.



- **Chapter R: Basic Concepts from Algebra and Geometry**

This new chapter provides a review of essential material from prerequisite courses, concentrating on skills used in algebra and geometry. Students are referred to this chapter by Algebra and Geometry Review Notes placed in the margins of the text. For example, students who need extra practice factoring trinomials are referred “just in time” to the proper section in Chapter R.

- **Appendix A: A Library of Functions**

This appendix is new and summarizes many of the basic functions and families of functions.

- **Appendix B: The TI-83/83 Plus Graphing Calculators**

This appendix has been expanded from the first edition to provide more help with graphing calculators. It contains specific keystrokes for working selected examples from the text. The Graphing Calculator Help notes in the margin of the text refer students to specific pages in Appendix B.

## FEATURES

- **Chapter and Section Introductions**

Many college algebra students have little or no understanding of mathematics. Chapter and section introductions motivate and explain some of the reasons for studying mathematics. (See pages 1, 65, 157, 221, and 268.)

- **Applications and Models**

Interesting, relevant applications are a major strength of this textbook, and as a result, students become more effective problem solvers and have a better understanding of how mathematics is used in the real world. Because the applications are intuitive and not overly technical, they can be introduced with a minimum amount of class time. Current data are used to create meaningful mathematical models. A unique feature of this text is that the applications and models are woven into both the discussions and the exercises. It is easier for students to learn how to solve applications if they are discussed within the text. (See pages 26, 165–166, 218, 334, and 349–351.) An Index of Applications is included at the end of the book.

- **Sources**

Since there are numerous applications throughout the text, genuine sources and a comprehensive bibliography are given. These sources reinforce for the student the practical applications of mathematics in real life. (See pages 104–106, and 387–390.)

- **Algebra and Geometry Review Notes**

Throughout the text, Algebra and Geometry Review Notes are located in the margins, which direct students “just in time” to Chapter R, where important topics in algebra and geometry are reviewed. Instructors can use this chapter for extra review or refer students to it as needed. This feature *free*s instructors from frequently reviewing material from intermediate algebra and geometry. (See pages 77 and 101.)

- **Graphing Calculator Help Notes**

The Graphing Calculator Help Notes located in the margins direct students “just in time” to Appendix B: The TI-83/83 Plus Graphing Calculators. This appendix shows students the necessary keystrokes to complete specific examples from the text. This feature *free*s instructors from teaching the specifics of the graphing calculator and gives students a convenient reference written specifically for this text. (See pages 7, 79, and 183.)

- **Making Connections**

This feature occurs throughout the text and helps students see how concepts covered previously are related to new concepts being presented. (See pages 30, 84, and 179.)

- **Putting It All Together**

This helpful feature at the end of each section summarizes techniques and reinforces the mathematical concepts presented in the section. It is given in an easy-to-follow grid. (See pages 52–53, 319–320, and 383–384.)

- **Checking Basic Concepts**

This feature includes a small set of exercises provided after every two sections that can be used for review. These exercises require about 15 or 20 minutes to complete and can be used for collaborative learning exercises, if time permits. (See pages 91, 188, and 311.)

- **Class Discussion**

This feature is included in most sections and poses a question that can be used for either classroom discussion or homework. (See pages 32, 124, and 229.)

- **Extended and Discovery Exercises**

Extended and Discovery Exercises occur at the end of selected sections and at the end of every chapter. These exercises are usually more complex and challenging, and often require extension of a topic presented or discovery of a new topic. They can be used for either collaborative learning or extra homework assignments. (See pages 172–173, 218–219, and 446–447.)

- **Exercise Sets**

The exercise sets are the heart of any mathematics text, and this text includes a large variety of instructive exercises. Each set of exercises involves skill building, mathematical concepts, and applications. Graphical interpretation and tables of data are often used to extend students' understanding of mathematical concepts. The exercise sets are graded carefully and categorized according to topic, which makes it easy for an instructor to select appropriate assignments. (See pages 168–173 and 346–352.)

- **Chapter Review Exercises**

This exercise set contains both skill-building and applied exercises. They stress different techniques for solving problems and provide students with the review necessary to pass a chapter test. (See pages 60–62 and 328–331.)

- **Chapter Summaries**

Chapter summaries are expanded and presented in an easy-to-read grid. They allow students to quickly review key concepts from the chapter. (See pages 213–215 and 324–327.)

## **SUPPLEMENTS**

### **For the Student**

**Student's Solutions Manual** ISBN 0-321-09162-0. This manual provides complete solutions to all odd-numbered exercises, excluding Checking Basic Concepts and Extended and Discovery Exercises.

**Videotape Series** ISBN 0-321-09166-3. Keyed to the text, these videotapes feature an engaging team of lecturers who provide comprehensive coverage of each section



and every topic (with the exception of Chapter R). In their presentations the lecturers use worked-out examples, visual aids, and manipulatives to emphasize the relevance of the material to students' everyday lives.

**Digital Video Tutor** ISBN 0-321-09576-6. The videotape series for this text is available on CD-ROM, which makes it convenient for students to watch video segments from a computer at home or on campus. This complete set of videos, now affordable for students and portable, is ideal for distance learning or extra instruction.

**InterAct Math<sup>®</sup> Tutorial Software** (CD for Windows) ISBN 0-321-09167-1. Professional software engineers working closely with a team of experienced math educators have designed and developed this software program. It includes exercises that are linked with every objective in the textbook and that require the same computational and problem-solving skills as their companion exercises in the text. Each exercise has an example and an interactive guided solution that are designed to involve students in the solution process and to help them identify precisely where they are having trouble. The software recognizes common student errors and provides students with appropriate customized feedback. With its sophisticated answer-recognition capabilities, *InterAct Math Tutorial Software* recognizes appropriate forms of one answer for any kind of input. It also tracks student activity and scores for each section, which can then be printed out. The software is free to qualifying adopters or can be bundled with books for sale to students.

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**Web Site.** The Web site for this text [www.aw.com/rockswold](http://www.aw.com/rockswold) provides additional resources for both students and instructors. These include downloadable graphing calculator programs for the TI-83/83+, instructions for using the TI-85 and TI-86 model graphing calculators, PowerPoint slides, chapter quizzes, and a tutorial program.

### For the Instructor

**Instructor's Edition** ISBN 0-321-09055-1. This version of the text contains answers to all exercises.

**Instructor's Solutions Manual** ISBN 0-321-09163-9. This manual contains complete solutions to all text exercises.

**Instructor's Testing Manual** ISBN 0-321-09165-5. This supplement provides prepared tests for each chapter of the main text.

**TestGen-EQ with QuizMaster-EQ<sup>®</sup>** (dual platform for Windows and Macintosh) ISBN 0-321-09169-8. This computerized test generator contains algorithmically defined problems organized specifically for this textbook. Its user-friendly graphical interface enables instructors to select, view, edit, and add test items, then print tests in a variety of fonts and forms. A built-in question editor gives the user the power to create graphs, import graphics, insert mathematical symbols and templates, and insert variable numbers or text. An "Export to HTML" feature lets instructors create practice tests that can be posted to a Web site. Tests created with *TestGen-EQ* can also be displayed on Web pages when the free *TestGen-EQ* plug-in has been installed with Internet

Explorer or Netscape Navigator. Tests created with *TestGen-EQ* can be used with *QuizMaster-EQ*, which enables students to take exams on a computer network. *QuizMaster-EQ* automatically grades the exams, stores results on disk, and allows the instructor to view or print a variety of reports for individual students, classes, or courses.

**MyMathLab.** MyMathLab.com is a free one-stop solution for creating and managing an on-line mathematics course for distance learning or to supplement a traditional or self-paced course. It is based on Addison-Wesley mathematics textbooks and integrates interactive multimedia instruction. MyMathLab.com is powered by CourseCompass, a version of Blackboard™ designed specifically for Addison-Wesley, and offers a suite of communication tools that allows users to send e-mail, participate in bulletin board discussions, schedule class chats, provide collaboration tools for students, and more. For more information, visit our web site at [www.mymathlab.com](http://www.mymathlab.com) or contact your local Addison-Wesley representative for a live demonstration.

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Gary Rockswold

# Important Formulas and Equations

**Distance Formula**

$$d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}, \text{ where } d \text{ is the distance between } (x_1, y_1) \text{ and } (x_2, y_2)$$

**Midpoint Formula**

$$M = \left( \frac{x_1 + x_2}{2}, \frac{y_1 + y_2}{2} \right), \text{ where } M \text{ is the midpoint of the line segment with endpoints } (x_1, y_1) \text{ and } (x_2, y_2)$$

**Slope of a Line**

$$m = \frac{y_2 - y_1}{x_2 - x_1}, \text{ where the line passes through } (x_1, y_1) \text{ and } (x_2, y_2)$$

**Slope-Intercept Form**

$$y = mx + b, \text{ where } m \text{ is the slope and } b \text{ is the } y\text{-intercept}$$

**Point-Slope Form**

$$y = m(x - x_1) + y_1, \text{ where } m \text{ is the slope and } (x_1, y_1) \text{ is a point on the line}$$

**Horizontal Line**

$$y = b, \text{ where the horizontal line has } y\text{-intercept } b$$

**Vertical Line**

$$x = k, \text{ where the vertical line has } x\text{-intercept } k$$

**Quadratic Formula**

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}, \text{ where } ax^2 + bx + c = 0, a \neq 0$$

**Vertex Formula**

$$x = -\frac{b}{2a} \text{ gives the } x\text{-coordinate of the vertex on the graph of } y = ax^2 + bx + c, a \neq 0$$

**Average Rate of Change of  $f$  from  $x_1$  to  $x_2$** 

$$\frac{y_2 - y_1}{x_2 - x_1}, \text{ where the graph of } f \text{ passes through } (x_1, y_1) \text{ and } (x_2, y_2)$$

**Vertex Form of a Parabola**

$$y = a(x - h)^2 + k, \text{ where } (h, k) \text{ is the vertex}$$

**Standard Equation of a Circle**

$$(x - h)^2 + (y - k)^2 = r^2, \text{ where } r \text{ is the radius and } (h, k) \text{ is the center}$$



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