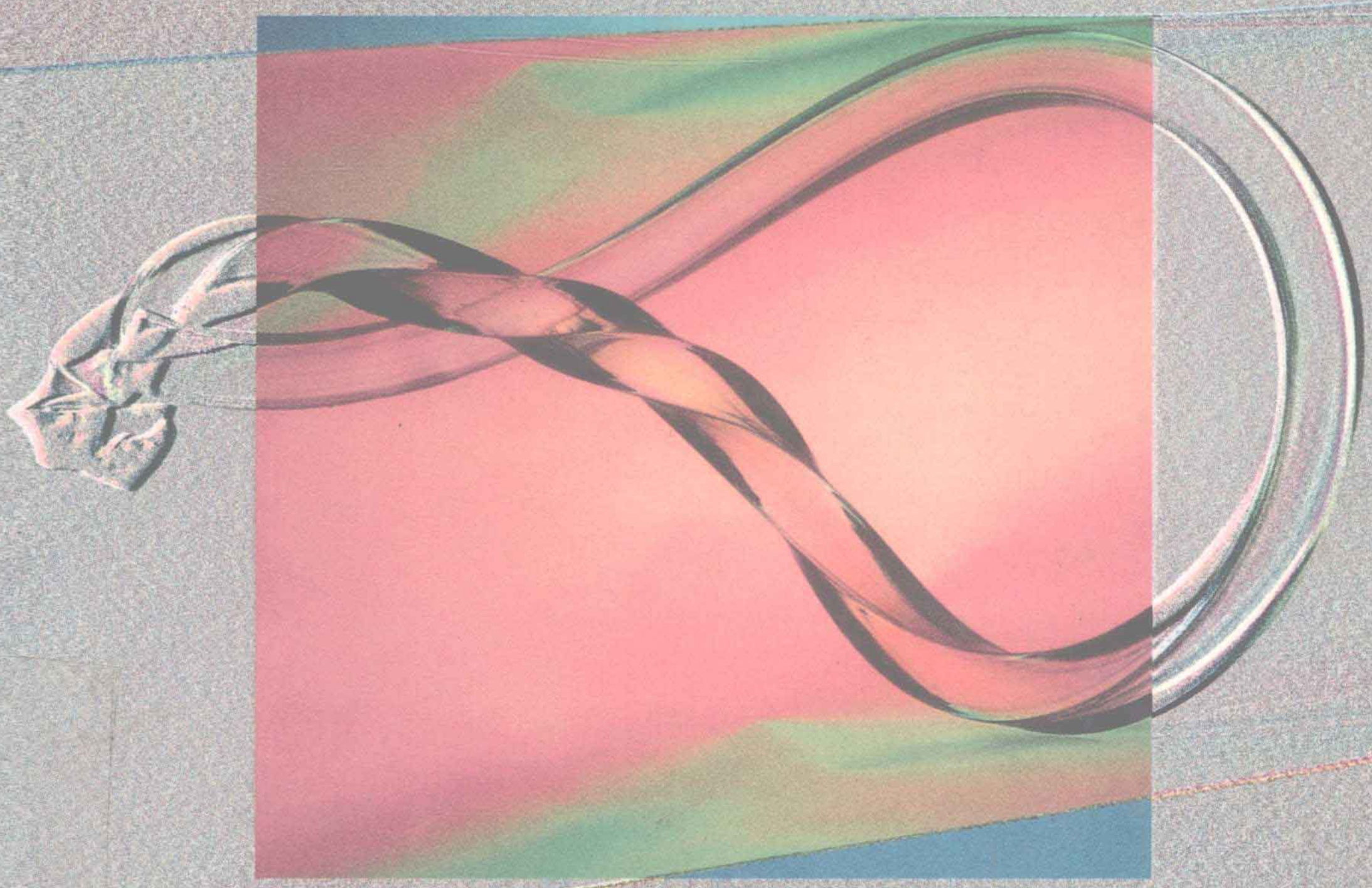
Charles P. McKeague

Elementary Algebra

EDITION



ELEMENTARY Algebra

FIFTH ▶ EDITION

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Cuesta College

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PREFACE TO THE INSTRUCTOR

This fifth edition of *Elementary Algebra* retains the same basic format and style as the fourth edition. It is designed for use in a lecture-format class with students who have no prior experience in algebra.

Features of the Book

Chapter Openers New to this edition, each chapter opens with the following three elements:

1. *Introduction* Each chapter opens with an introduction in which a real-world application, historical example, or a link between topics is used to stimulate interest in the chapter. Whenever possible, these introductions are expanded on later in the chapter and then carried through to topics found further on in the book.
2. *Overview* A general overview of the chapter follows the chapter introduction. The overview lists the important topics that will be covered in the chapter, along with their connection to one another and to topics covered previously in the text. Most of the overviews end with a list of topics from previous chapters that students need to know in order to be successful in the current chapter.
3. *Study Skills* Found in the first six chapter openers is a list of study skills intended to help students become organized and efficient with their time. The study skills point students in the direction of success. They are intended to benefit students in this course and throughout their college careers. These skills are more detailed than the general study skills listed in the Preface to the Student.

Organization of the Problem Sets Five main ideas are incorporated into each problem set.

1. *Drill* There are enough problems in each set to ensure student proficiency in the material.

2. *Progressive Difficulty* The problems increase in difficulty as the problem set progresses.
3. *Odd-Even Similarities* Each pair of consecutive problems is similar. Since the answers to the odd-numbered problems are listed in the back of the book, the similarity of the odd-even pairs of problems allows your students to check their work on an odd-numbered problem and then to try the similar even-numbered problem.
4. *Application Problems* Students are always curious about how the algebra they are learning can be applied, but at the same time many students are apprehensive about attempting application problems. I have found that they are more likely to put some time and effort into trying application problems if they do not have to work an overwhelming number of them at one time and if they work on them every day. For these reasons, I have placed a few application problems toward the end of almost every problem set in the book.
5. *Review Problems* As was the case in the fourth edition, each problem set, beginning with Chapter 2, contains a few review problems. Where appropriate, the review problems cover material that will be needed in the next section. Otherwise they cover material from the previous chapter. That is, the review problems in Chapter 5 cover the important points covered in Chapter 4. Likewise, the review problems in Chapter 6 review the important material from Chapter 5. If you give tests on two chapters at a time, you will find this to be a time-saving feature. Your students will review one chapter as they study the next chapter.

Blueprint for Problem Solving New to this edition, the Blueprint for Problem Solving is a detailed outline of the steps needed to successfully attempt application problems. Intended as a guide to problem solving in general, the blueprint overlays the solution process to all the application problems in the first few chapters of the book. As students become more familiar with problem solving, the steps in the blueprint are streamlined.

Research Projects Scattered throughout this edition are problems for students to research and then report on. Although they appear at the end of a number of the problem sets, they are not intended to be part of the student's daily assignment. In my classes, these are the problems I use for extra credit. In most cases, I require students to type their reports, just as they would type an essay in their English classes. Do not be concerned if you are not familiar with the topics shown in the research projects; the idea behind these projects is to have your students do the research, and then tell you what they have learned.

Chapter Summaries Each chapter summary lists the new properties and definitions found in the chapter. The margins in the chapter summaries contain examples that illustrate the topics being reviewed.

Chapter Reviews Each chapter ends with a set of review problems that cover all the different types of problems found in the chapter. The chapter reviews are longer and more extensive than the chapter tests.

Chapter Tests Each chapter test contains a representative sample of the problems covered in the chapter.

Changes in the Fifth Edition

In addition to the chapter openers, research projects, and Blueprint for Problem Solving mentioned above, the followings items are also new to this edition.

Increased Visualization of Topics This edition contains many more diagrams, charts, and graphs than the previous edition. Their purpose is to give students additional information, in visual form, to help them understand the topics we cover.

Facts from Geometry Many of the important facts from geometry are now listed under this heading. In most cases, an example or two accompanies each of the facts to give students a chance to see how topics from geometry are related to the algebra they are learning.

Number Sequences An introductory coverage of number sequences is integrated throughout Chapter 1 and then expanded and continued in Chapters 2 and 3. I find that there are many interesting topics I can cover if students have some experience with number sequences. It is also the easiest way to demonstrate inductive reasoning.

Tables, Histograms, Scatter Diagrams, and Line Graphs Beginning in Chapter 1 and then continued in Chapters 3 and 4, students are required to analyze information from tables. In addition to simply reading a table, they are given practice converting data in tabular form to data in graphical form that includes histograms and scatter diagrams. (Why not? Histograms, scatter diagrams, and line graphs are what they see if they read a newspaper or magazine.) From there they move on to graph ordered pairs and linear equations on a rectangular coordinate system. Section 3.1 has been rewritten completely to accommodate this new feature.

Unit Analysis Chapter 6 now contains problems requiring students to convert from one unit of measure to another. The method used to accomplish the conversions is the method they will use if they take a chemistry class. Since this method is similar to the method we use to multiply rational expressions, unit analysis is covered in Section 6.2 with multiplication and division of rational expressions.

Challenging Problems and Application Problems More challenging problems have been added to many of the problem sets. Some of the new problems are in the drill problem category, while many others are new, more realistic, application problems.

Supplements to the Textbook

This fifth edition of *Elementary Algebra* is accompanied by a number of useful supplements.

For the Instructor

- **Instructor's Edition** An instructor version of the text is available to facilitate accessible and effective teaching. All answers to the problem sets are provided.
- **Instructor's Solution Manual** The manual supplies instructor-appropriate solutions for half the odd and all the even exercises in the problem sets. Solutions for all other exercises comprise the Student's Solutions Manual.
- **Printed Test Bank and Prepared Tests** The test bank consists of multiple-choice test items organized by chapter, section, and objective. The prepared tests comprise 10 sets of ready-to-copy tests: one set for each chapter and one set for the entire book. Each set comprises two multiple-choice and four show-your-work tests. Items for half of the tests are ordered according to the sequence of topics in the book; items for the other half of the tests are in mixed-up order. Answers for every test item are provided.
- ***ExaMaster*+™ Computerized Test Bank** A flexible, powerful, computerized testing system, *ExaMaster*+™ offers teachers a wide range of integrated testing options and features. Available in IBM, Macintosh, or Windows format, it offers teachers the ability to select, edit, or create not only test items but algorithms for test items as well. Teachers can tailor tests according to a variety of criteria, scramble the order of test items, and administer tests on-line. *ExaMaster*+™ also includes full-function gradebook and graphing features.

For the Student

- **Videotape Package** Free to adopters, the videotape package consists of 9 VHS videotapes, one for each chapter of the book. Each chapter tape is an hour to an hour and a half in length and is divided into lessons that correspond to each section of the chapter.
- **Student's Solutions Manual** This manual contains complete annotated solutions to every other odd problem in problem sets and all chapter review and chapter test exercises.
- **MathCue Tutorial** This computer software package of tutorials has problems that correspond to every section in the series. The software presents problems to solve and tutors students by displaying annotated, step-by-step solutions. Students may view partial solutions to get started on a problem, see continuous record of progress, and back up to review missed problems. Student scores can also be printed. Available for IBM and Macintosh.
- **MathCue Solution Finder** This software allows students to enter their own problems into the computer and get annotated, step-by-step solutions in return. This unique program simulates working with a tutor, tracks student progress, refers students to specific sections in the text when appropriate, and prints student scores. Available for IBM and Macintosh.

- **MathCue Practice** This algorithm-based software allows students to generate large numbers of practice problems keyed to problem types from each section of the book. Practice scores students' performance, and saves students' scores session to session. Available for IBM and Macintosh.

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Charles P. McKeague

PREFACE TO THE STUDENT

I often find my students asking themselves the question "Why can't I understand this stuff the first time?" The answer is "You're not expected to." Learning a topic in algebra isn't always accomplished the first time around. There are many instances when you will find yourself reading over new material a number of times before you can begin to work problems. That's just the way things are in algebra. If you don't understand a topic the first time you see it, that doesn't mean there is something wrong with you. Understanding algebra takes time. The process of understanding requires reading the book, studying the examples, working problems, and getting your questions answered.

Here are some questions that are often asked by students starting a beginning algebra class.

How much math do I need to know before taking algebra? You should be able to do the four basic operations (addition, subtraction, multiplication, and division) with whole numbers, fractions, and decimals. Most important is your ability to work with whole numbers. If you are a bit weak at working with fractions because you haven't worked with them in a while, don't be too concerned; we will review fractions as we progress through the book. I have had students who eventually did very well in algebra, even though they were initially unsure of themselves when working with fractions.

What is the best way to study? The best way to study is to study consistently. You must work problems every day. A number of my students spend an hour or so in the morning working problems and reading over new material and then spend another hour in the evening working problems. The students of mine who are most successful in algebra are the ones who find a schedule that works for them and then stick to it. They work problems every day.

If I understand everything that goes on in class, can I take it easy on my homework? Not necessarily. There is a big difference between understanding a problem someone else is working and working the same problem yourself. There is no substitute for working problems yourself. The concepts and properties are understandable to you only if you yourself work problems involving them.

How to Be Successful in Algebra

If you have decided to be successful in algebra, then the following list will be important to you.

1. **Attend all class sessions on time** You cannot know exactly what goes on in class unless you are there. Missing class and then expecting to find out what went on from someone else is not the same as being there yourself.
2. **Read the book** It is best to read the section that will be covered in class beforehand. Reading in advance, even if you do not understand everything you read, is still better than going to class with no idea of what will be discussed.
3. **Work problems every day and check your answers** The key to success in mathematics is working problems. The more problems you work, the better you will become at working them. The answers to the odd-numbered problems are given in the back of the book. When you have finished an assignment, be sure to compare your answers with those in the book. If you have made a mistake, find out what it is, and correct it.
4. **Do it on your own** Don't be misled into thinking someone else's work is your own. Having someone else show you how to work a problem is not the same as working the same problem yourself. It is okay to get help when you are stuck. As a matter of fact, it is a good idea. Just be sure you do the work yourself.
5. **Review every day** After you have finished the problems your instructor has assigned, take another fifteen minutes and review a section you have already completed. The more you review, the longer you will retain the material you have learned.
6. **Don't expect to understand every new topic the first time you see it** Sometimes you will understand everything you are doing, and sometimes you won't. That's just the way things are in mathematics. Expecting to understand each new topic the first time you see it can lead to disappointment and frustration. The process of understanding algebra takes time. It requires that you read the book, work problems, and get your questions answered.
7. **Spend as much time as it takes for you to master the material** No set formula exists for the exact amount of time you need to spend on algebra to master it. You will find out as you go along what is or isn't enough time for you. If you end up spending two or more hours on each section in order to master the material there, then that's how much time it takes; trying to get by with less will not work.
8. **Relax** It's probably not as difficult as you think.

CONTENTS

CHAPTER 1

THE BASICS

INTRODUCTION

Much of what we do in mathematics is concerned with recognizing patterns and classifying together groups of numbers that share a common characteristic. Two groups of numbers that we will study in this chapter are shown below. Each of the groups forms a pattern. As you will see, the characteristic shared by the numbers in each of these sequences can be described with algebra.

Sequence of odd numbers = 1, 3, 5, 7, 9, . . .
Sequence of squares = 1, 4, 9, 16, 25, . . .

Once we have classified groups of numbers as to the characteristics they share, we sometimes discover that a relationship exists between the groups. Although it may not be obvious at first, there is a relationship that exists *between* the two sequences shown above. The relationship has been known for some time. In *The Book of Squares,* written by the mathematician known as Fibonacci in 1225, Fibonacci begins the introduction this way:

> I thought about the origin of all square numbers and discovered that they arise out of the increasing sequence of odd numbers.

The relationship that Fibonacci refers to (and that you will discover later in this chapter) can be described very concisely with algebra.

OVERVIEW

Chapter 1 contains some of the most important material in the book. Your goal is to master it. Your success in the following chapters depends upon how well you understand Chapter 1. Here is a list, in order of importance, of the ideas you must know after you complete this chapter.

1. You *must* know how to add, subtract, multiply, and divide positive and negative numbers.
2. You *must* understand and recognize when the commutative, associative, and distributive properties are being used.

3. You should know the major classifications of numbers. That is, you should know the difference between whole numbers, integers, rational numbers, and real numbers.

Study Skills

Some of the students enrolled in my beginning algebra classes develop difficulties early in the course. Their difficulties are not associated with their ability to learn mathematics; they all have the potential to pass the course. Students who get off to a poor start do so because they have not developed the study skills necessary to be successful in algebra; they do not put themselves on an effective homework schedule, and when they work problems, they do it their way, not my way. Here is a list of things you can do to begin to develop effective study skills.

1. **Put Yourself on a Schedule** The general rule is that you spend two hours on homework for every hour you are in class. Make a schedule for yourself in which you set aside two hours each day to work on algebra. Once you make the schedule, stick to it. Don't just complete your assignments and stop. Use all the time you have set aside. If you complete an assignment and have time left over, read the next section in the book, and then work more problems.
2. **Find Your Mistakes and Correct Them** There is more to studying algebra than just working problems. You must always check your answers with the answers in the back of the book. When you have made a mistake, find out what it is, and correct it. Making mistakes is part of the process of learning mathematics. In the prologue to *The Book of Squares,* Fibonacci has this to say about the content of his book:

   > I have come to request indulgence if in any place it contains something more or less than right or necessary; for to remember everything and be mistaken in nothing is divine rather than human . . .

   Fibonacci knew, as you know, that human beings make mistakes. You cannot learn algebra without making mistakes.
3. **Imitate Success** Your work should look like the work you see in this book and the work your instructor shows. The steps shown in solving problems in this book were written by someone who has been successful in mathematics. The same is true of your instructor. Your work should imitate the work of people who have been successful in mathematics.

SECTION 1.1

Notation and Symbols

Since much of what we do in algebra involves comparison of quantities, we will begin by listing some symbols used to compare mathematical quantities. The comparison symbols fall into two major groups: equality symbols and inequality symbols. Before going further, we need to say a few words about variables.

Variables: An Intuitive Look

When you filled out the application for the school you are attending, there was a space to fill in your first name. ''First Name'' is a variable quantity, because the value it takes on depends on who is filling out the application. For example, if your first name is Manuel, then the value of ''First Name'' is Manuel. On the other hand, if your first name is Christa, then the value of ''First Name'' is Christa.

If we denote ''First Name'' as *FN*, ''Last Name'' as *LN*, and ''Whole Name'' as *WN*, then we take the concept of a variable further and write the relationship between the names this way:

$$FN + LN = WN$$

(We use the + symbol loosely here to represent writing the names together with a space between them.) This relationship we have written holds for all people who have only a first name and a last name. For those people who have a middle name, the relationship between the names is

$$FN + MN + LN = WN$$

A similar situation exists in algebra when we let a letter stand for a number or a group of numbers. For instance, if we say ''let a and b represent numbers,'' then a and b are called **variables** because the values they take on vary. We use the variables a and b in the lists below so that the relationships shown there are true for all numbers that we will encounter in this book. By using variables, the statements written below are general statements about all numbers, rather than specific statements about only a few numbers.

Comparison Symbols

Equality:	$a = b$	a is equal to b (a and b represent the same number)
	$a \neq b$	a is not equal to b
Inequality:	$a < b$	a is less than b
	$a \not< b$	a is not less than b
	$a > b$	a is greater than b
	$a \not> b$	a is not greater than b
	$a \geq b$	a is greater than or equal to b
	$a \leq b$	a is less than or equal to b

The symbols for inequality, $<$ and $>$, always point to the smaller of the two quantities being compared. For example, $3 < x$ means 3 is smaller than x. In this case, we can say ''3 is less than x'' or ''x is greater than 3''; both statements are