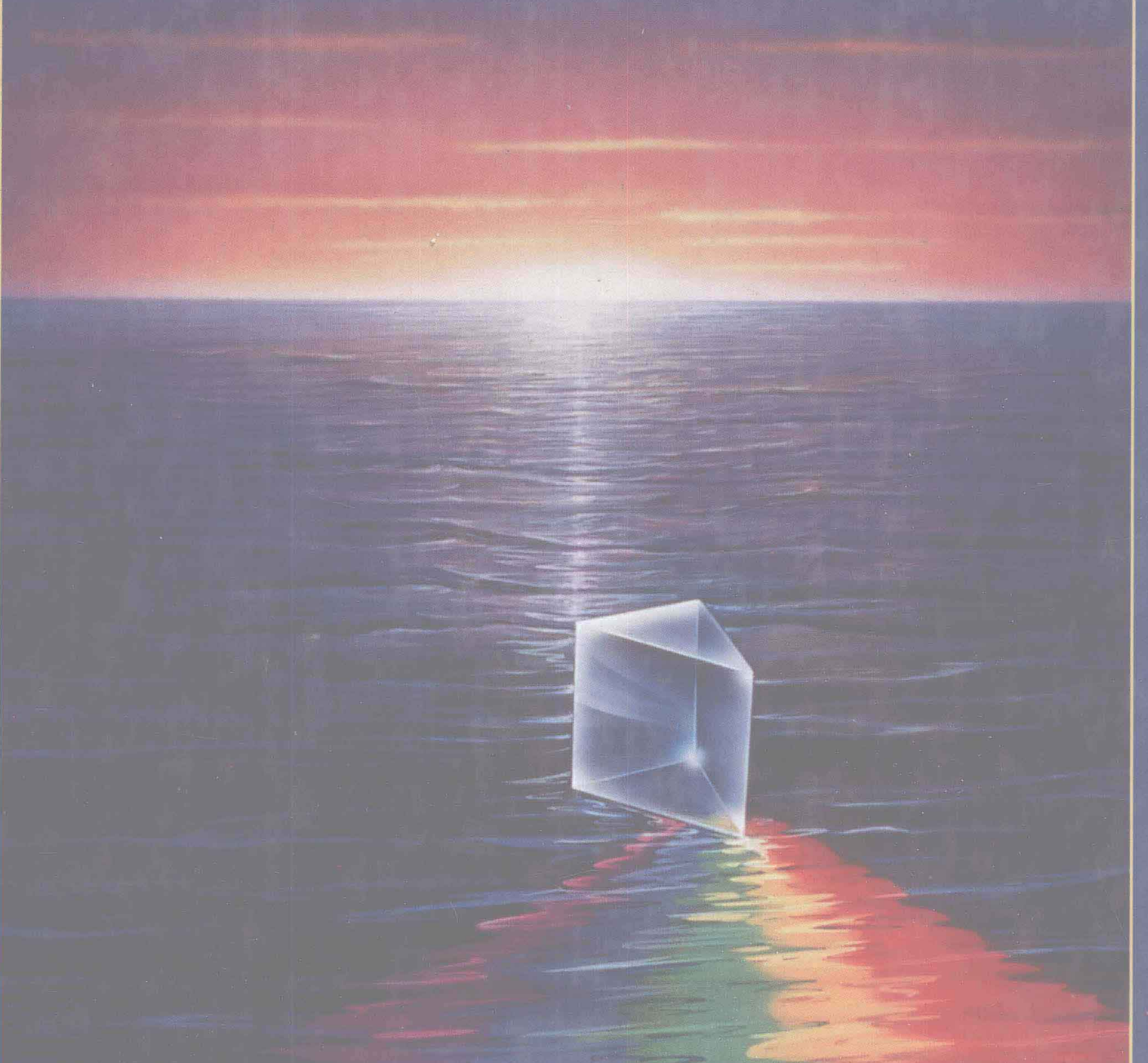
UNDERSTANDING INTERMEDIATE ALGEBRA

A GRAPHING APPROACH



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Understanding Intermediate Algebra

A Graphing Approach

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Preface to the Instructor

Purpose

The last several years have been a time of much introspection by the mathematics community with regard to traditional curricula and courses of study. In particular, the new NCTM and AMATYC guidelines have stimulated much discussion as to what should be emphasized and de-emphasized in the traditional preparatory algebra curriculum.

This textbook reflects our belief that students can learn algebra if they are given the opportunity to understand what they are doing and why. Without sacrificing what our users have liked most about our previous texts, this text attempts to take advantage of the graphing calculator technology now so widely available, to motivate and explain algebraic ideas from a geometric (graphical) perspective as well.

This new technology allows us to visualize concepts and apply them to more realistic situations. In particular, a graphing calculator with a table-building capability makes it natural to approach problems from three complementary perspectives: the traditional algebraic point of view (which we believe still has much to offer), the numerical point of view (which the table-building capability allows us to employ), and the graphical (geometric) point of view.

The use of the new technology and these various points of view allow us to attack a wide variety of realistic problems for which we obtain exact and approximate solutions as the situation allows. We treat the calculator as we would pencil and paper—as another tool students bring with them to the problem-solving process. In addition, the graphing calculator is employed as a learning tool: The students are encouraged to use the graphing calculator to explore and discover mathematical relationships for themselves. Finally, the use of a graphing calculator allows a natural introduction to the concept of functions early in the text. Functions are used as a unifying concept throughout the text.

Every effort has been made to involve the student in the learning process. This is done primarily through the use of very carefully constructed illustrative examples designed to prevent the student from being a passive "reader" rather than an active "thinker." The illustrative examples are replete with side comments designed to actively involve the student in the process of problem solving. Additionally, the text material contains margin comments to further engage the student to think carefully about what is being said.

This text is written with what we firmly believe is a realistic expectation that students can learn algebra if we take the time to *explain* where we are, where we are going, and how we plan to get there.

In a text at this level it is obvious that the algebraic steps taken in the solution to a problem need to be illustrated and explained. Similarly, we feel strongly that to truly integrate the calculator into the problem-solving techniques discussed in this text, we must include specific keystroke sequences needed to carry out the calculation. In addition, the keystroke sequences are accompanied by explanations of what the calculator is doing and why, just as we annotate the steps in an algebraic solution.

We have decided to key this text to the Texas Instruments TI-82 for a variety of reasons. First, its table-building capability lends itself quite well to a numerical analysis of relationships. Second, the TI-82 seems to be a very popular calculator with widespread use throughout the country. (The few minor relevant differences between the TI-82 and the TI-83 are identified in the Preface to the Student.)

Please keep in mind that there is an accompanying graphing calculator manual which explains how to carry out the operations used in this text on other popular calculators (see the **Supplements** section below).

As with *Understanding Intermediate Algebra,* 3rd Edition, we offer a view of algebra that takes evey opportunity to explain why things are done in a certain way, to show how concepts or topics are related, and to show how supposedly "new" topics are actually just new applications of concepts already learned.

This text assumes a knowledge of elementary algebra. However, we realize that students arrive in intermediate algebra with a diversity of previous mathematical experiences. Some may have recently learned elementary algebra but to varying degrees; some may have learned elementary algebra well but have been away from it for a while. In this spirit, we have tried to develop a text flexible enough to meet the needs of this heterogeneous group by providing explanations for what we regard as key elementary concepts that are crucial to the understanding of the more difficult intermediate algebra concepts. The less well prepared students certainly benefit from these explanations; the better prepared students appreciate this second look as a way to help them fit the seemingly unrelated parts of algebra together. The instructor has the choice of discussing this material or leaving it for students to review on their own.

Pedagogy

We believe that a student can successfully learn and understand algebra by mastering the basic concepts and being able to apply them to a wide variety of situations. Thus, each section begins by relating the topic to be discussed to material previously learned. In this way the students can see algebra as a whole rather than as a series of isolated ideas. Many sections begin with a real-life application to motivate the topic to be discussed.

Basic concepts, rules, and definitions are motivated and explained via numerical, analytic (algebraic), and graphical examples.

Concepts are developed in a series of carefully constructed illustrative examples. Through the course of these examples we compare and contrast related ideas, helping the student to understand the sometimes subtle distinctions among various situations. In addition, these examples strengthen a student's understanding of how this "new" idea fits into the overall picture.

Every opportunity has been taken to point out common errors often made by students and to explain the misconception that often leads to a particular error.

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Basic rules and/or procedures are highlighted so that students can find important ideas quickly and easily.

Early Functions The concept of functions is introduced early, starting at an elementary level in Chapter 2 and spiraling throughout the text; more sophisticated function concepts are covered in Chapter 9.

The Graphing Calculator as a Mathematical Tool The graphing calculator is used as a tool in solving mathematical problems. The student is encouraged to use the calculator where it is appropriate and discouraged from using the calculator where it is not; the decision whether or not to use the calculator is considered an important part of the learning process (Section 3.5).

The Graphing Calculator as a Learning Tool Within the text and exercises, students are asked to use the calculator to verify conclusions, explore concepts, and discover relationships (Section 4.1, Example 4).

Hands-On Use of Graphing Calculator Keystrokes are provided to encourage students to use the graphing calculator as they read the text (Section 4.3). In addition to providing the keystrokes, the text explains what the calculator is doing. This helps the student acquire the ability to analyze a problem, develop a problem-solving strategy, and then use a graphing calculator to solve it.

Features

The various steps in the solutions to examples are explained in detail. Many steps appear with annotations (highlighted in color) that involve the student in the solution. These comments explain how and why a solution is proceeding in a certain way.

- There are over 6,300 exercises, including calculator exercises. Not only have the exercise sets been matched odd/even, but they have also been designed so that, in many situations, successive odd-numbered exercises compare and contrast subtle differences in applying the concepts covered in the section. Additionally, variety has been added to the exercise sets so that the student must be alert as to what the problem is asking. For example, the exercise sets in Sections 2.3 and 6.5, which deal primarily with solving rational equations, also contain some exercises on adding rational expressions.
- One of the main sources of students' difficulties is that they do not know how to study algebra. In this regard we offer a totally unique feature. The preface to the student and each section in the first four chapters conclude with a **Study Skill.** This is a brief paragraph discussing some aspect of studying algebra, doing homework, or preparing for or taking exams. Our students have indicated that they found the Study Skills very helpful. The study skills appearing in this text are part of a collection of general mathematics study skills developed by Lewis R. Hirsch and Mary C. Hudspeth at the Pennsylvania State University. For a more detailed discussion of how to study mathematics, we refer you to the book *Studying Mathematics* by M. C. Hudspeth and L. R. Hirsch (1982, Kendall/Hunt Publishing Company, Dubuque, Iowa).
- Almost every exercise set contains **Questions for Thought,** which offer the student an opportunity to *think* critically about various algebraic ideas. They may be

asked to compare and contrast related ideas, or to examine an incorrect solution and explain why the solution is wrong. The Questions for Thought are intended to be answered in complete sentences and in grammatically correct English. The Questions for Thought were originally designed for having students write across the curriculum, and can be used by instructors for this purpose.

- **Margin Comments** Scattered throughout the text, questions and comments placed in the margin are specifically designed to involve the student more actively in the development (Section 2.1, Examples 4 and 6).
- **Different Perspectives** Different Perspectives boxes appear wherever there is an opportunity to highlight the connection between the algebraic and geometric interpretations of the same concept. In this way the student is encouraged to think about mathematical ideas from more than one point of view (Section 3.5).
- **Thinking Out Loud** The solutions for certain problems are presented in a question-and-answer format, so that students can see examples of the thought processes involved in approaching and solving new or unfamiliar problems. In this way the students will develop appropriate problem-solving strategies (Section 8.8, Example 8).
- **Technology Corner** Appearing at the end of a number of sections, this feature points out alternative or additional features of the graphing calculator that can be used to solve mathematical problems.
- Each chapter contains a chapter summary describing the basic concepts in the chapter. Each point listed in the summary is accompanied by an example illustrating the concept or procedure.
- Each chapter contains a set of chapter review exercises and a chapter practice test. Additionally, there are four cumulative review exercise sets and four cumulative practice tests, following Chapters 3, 6, 9, and 11. These offer the student more opportunities to practice choosing the appropriate procedure in a variety of situations.
- The answer section contains answers to all the odd-numbered exercises, as well as to *all* review exercises and practice test problems. The answer to each verbal problem contains a description of what the variable(s) represent and the equation (or system of equations) used to solve it. In addition, the answers to the cumulative review exercises and cumulative practice tests contain a reference to the section in which the relevant material is covered.
- Most sections contain a **Mini-Review,** which consists of exercises that allow students to periodically review important topics as well as help them prepare for the material to come. These Mini-Reviews afford the student additional opportunity to see new topics within the framework of what they have already learned.

Supplements

The following supplements are available for users of this text.

- **Instructor's Solution Manual,** by Cheryl Roberts of Northern Virginia Community College, includes detailed solutions to all the even-numbered exercises.
- **Student's Solution Manual,** by Cheryl Roberts of Northern Virginia Community College, provides detailed solutions for the odd-numbered exercises from the text.
- **Instructor's Manual with Test Bank,** by Norma James of New Mexico State University, includes sample syllabi, suggested course schedule, chapter objectives,

homework assignments, chapter tests, and a test bank containing 100 questions and 5 algorithms per chapter.

- **Graphing Technology Laboratory Manual,** by David Lawrence of Southwestern Oklahoma State University, includes keystroke instructions for various types of graphing calculators—Texas Instruments, Casio, Sharp, and Hewlett-Packard, as well as Derive software.
- **WESTEST,** a computer-generated testing program, includes algorithmically generated questions and is available in both Macintosh and PC versions.
- **Interactive Algebra** tutorial software, by Chuck Sterner, is available for Macintosh and PC platforms.

Please ask your West representative about qualifications for these supplements.

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Finally, we would like to thank our wives, Cindy and Sora, and our families for their unwavering encouragement.

Preface to the Student

This text is designed to help you understand algebra. We are convinced that if you understand what you are doing and why, you will be a much better algebra student. (Our students who have used preliminary versions of this book seem to agree with us.) This does not mean that after reading each section you will understand all the concepts clearly. Much of what you learn comes through the course of doing lots and lots of exercises and seeing for yourself exactly what is involved in completing an exercise. However, if you read the textbook carefully and take good notes in class you will find algebra not quite so menacing.

Here are a few suggestions for using this textbook:

- Always read the textbook with a pencil and paper in hand. Reading mathematics is not like reading other subjects. *You* must be involved in the learning process. Work out the examples along with the textbook and *think* about what you are reading. Make sure you understand what is being done and why.
- You must work homework exercises on a daily basis. While attending class and listening to your instructor are important, do not mistake understanding someone else's work for the ability to do the work yourself. (Think about watching someone else driving a car, as opposed to driving yourself.) Make sure *you* know how to do the exercises.
- Read the Study Skills which follow this preface and appear at the end of each section in the first four chapters. They discuss the best ways to use the textbook and your notes. They also offer a variety of suggestions on how to study, do homework, and prepare for and take tests. For more information on improving your algebra study skills, we direct you to the book *Studying Mathematics,* by Mary Catherine Hudspeth and Lewis R. Hirsch (1982, Kendall/Hunt Publishing Company, Dubuque, Iowa).
- Do not get discouraged if you have difficulty with some topics. Certain topics may not be absolutely clear the first time you see them. Be persistent. We all need time to absorb new ideas and become familiar with them. What was initially difficult will become less so as you spend more time with a subject. Keep at it and you will see that you are making steady progress.

Using a Calculator

A graphing calculator is a very powerful tool for doing calculations quickly and accurately and for exploring graphs. When you sit down to work on a math problem you should have the tools you will need—pencil, paper, and calculator. Nevertheless, a calculator cannot substitute for understanding what you are doing and why.

In general, it is a good idea to work out as much of an exercise as you can on paper, and try to save any calculator computations for the last step. If you need to use a calculator for the intermediate steps in the solution to a problem, then be sure to write down the results of those steps. Writing the steps down helps you understand the problem and makes it easier to spot errors and check that the calculator answer makes sense (and that you used the calculator correctly); see Study Skill topic "Estimation" on page xix.

Knowing how and *when* to use a calculator for a problem can make a difference in the accuracy of your answer as well. In this text, unless otherwise specified, all equations require exact answers (answers that are not rounded). Suppose, for example, you need to enter $\frac{33}{7}$ in your calculator before using it in your calculations to solve an equation. If you round $\frac{33}{7}$ to 4.71, you will automatically introduce a rounding error in your calculations. (How much this error is magnified and reflected in the solution will depend on the operations performed on, or with, this number.) Your solution will not be exact. Even if you enter $\frac{33}{7}$ in your calculator as [3] [3] [÷] [7] [=], your calculator will round the number before performing computations; the result will be a more accurate answer, but it still may not be exact.

Consider another example concerning exact solutions. Suppose the solution to an equation is $\frac{5}{13}$. If the problem is solved correctly and all numbers are entered accurately, you should arrive at the answer 0.384615384615 using your calculator. While this answer is accurate to 12 decimal places, it is still a rounded answer, not the exact answer $\frac{5}{13}$. If you try checking this answer in the original equation, the answer may not check out.

To get the most out of your calculator, you need to become familiar with its various capabilities. One way to do this is to read the "Getting Started" sections, which deal with how the calculator operates.

We list the following general advice for using your calculator while working on algebra problems:

1. When an exact answer such as $\sqrt{3}$ or $\frac{3}{7}$ is requested or required, the calculator should *not* be used except possibly to *check* the accuracy of your computations.
2. When solving most problems, work out as much of the problem as possible on paper and save the calculator computations for the last step. This way you will be able to check the logic of the steps in your solution, spot errors, and check that the calculator answer makes sense. This also reduces errors due to rounding.
3. For some problems, you may not be able to save the computations for the last step—the problem may require that you use the calculator for many stages of the problem. Again, you should try to write down as many steps as you can so you can check over your work.
4. You *should* use your calculator to check all computations including checking your solution whenever possible. (If your answer is exact, keep in mind that the calculator may give a rounded answer.)

The calculator keystrokes illustrated in this text correspond to the TI-82 calculator. The newer TI-83 is a slight upgrade of the TI-82 and is identical in most respects. The following are the few differences which are relevant to the material presented in this text.

1. On the TI-83, the absolute value is found in the MATH **NUM** menu.
2. On the TI-83, the Y-VARS menu is accessed through the VARS **Y-VARS** menu.
3. On the TI-83, the **TblSet** screen uses **TblStart** instead of **TblMin**.
4. On the TI-83, in the **Calculate** menu, choice number 2 is called **zero** instead of **root**.

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Strengthening Your Study Skills

Studying Algebra—How Often?

In most college courses, you are typically expected to spend 2–4 hours studying outside of class for every hour spent in class.

It is especially important that you spend this amount of time studying algebra, since you must both acquire and *perfect* skills; and, as most of you who play a musical instrument or participate seriously in athletics already should know, it takes time and lots of practice to develop and perfect a skill.

It is also important that you distribute your studying over time. That is, do not try to do all your studying in 1, 2, or even 3 days, and then skip studying the other days. You will find that understanding algebra and acquiring the necessary skills are much easier if you spread your studying out over the week, doing a little each day. If you study in this way, you will need less time to study just before exams.

In addition, if your study sessions are more than 1 hour long, it is a good idea to take a 10-minute break within every hour you spend reading math or working exercises. The break helps to clear your mind, and allows you to think more clearly.

Previewing Material

Before you attend your next class, preview the material to be covered beforehand. First, skim the section to be covered, look at the headings, and try to guess what the sections will be about. Then read the material over carefully.

You will find that when you read over the material before you go to class, you will be able to follow the instructor more easily, things will make more sense, and you will learn the material more quickly. Now, if there was something you did not understand when you previewed the material, the teacher will be able to answer your questions *before* you work your assignment at home.

What to Do First

Before you attempt algebra exercises, either for homework or for practicing your skills, it is important to review the relevant portions of your notes and text.

Memorizing a bunch of seemingly unrelated algebraic steps to follow in an example may serve you initially, but in the long run (most likely before Chapter 3), your memory will be overburdened—you will tend to confuse examples and/or forget steps.

Reviewing the material before doing exercises makes each solution you go through more meaningful. The better you understand the concepts underlying the exercise, the easier the material becomes, and the less likely you are to confuse examples or forget steps.

When reviewing the material, take the time to *think about what you are reading.* Try not to get frustrated if it takes you an hour or so to read and understand a few pages of a math text—that time will be well spent. As you read your text and your notes, think about the concepts being discussed: **(a)** how they relate to previous concepts covered, and **(b)** how the examples illustrate the concepts being discussed. More than likely, worked-out examples will follow verbal material, so look carefully at these examples and try to understand why each step in the solution is taken. When you finish reading, take a few minutes and think about what you have just read.

Doing Exercises

After you have finished reviewing the appropriate material, you should be ready to do the relevant exercises. Although your ultimate goal is to be able to work out the exercises accurately *and* quickly, when you are working out exercises on a topic that is new to you it is a good idea to take your time and think about what you are doing while you are doing it.

Think about how the exercises you are doing illustrate the concepts you have reviewed. Think about the steps you are taking and ask yourself why you are proceeding in this particular way and not some other: Why this technique or step and not a different one?

Do not worry about speed now. If you take the time at home to think about what you are doing, the material becomes more understandable and easier to remember. You will then be less likely to "do the wrong thing" in an exercise. The more complex-looking exercises are less likely to throw you. In addition, if you think about these things in advance, you will need much less time to think about them during an exam, and so you will have more time to work out the problems.

Once you believe you thoroughly understand what you are doing and why, you may work on increasing your speed.

Reading Directions

One important but frequently overlooked aspect of an algebraic problem is the verbal instructions. Sometimes these instructions are given in a single word, such as "simplify" or "solve" (occasionally it takes more time to understand the instructions than it takes to do the exercise). The verbal instructions tell us what we are expected to do, so make sure you read the instructions carefully and understand what is being asked.

Two examples may look the same, but the instructions may be asking you to do two different things. For example:

Identify the following property:

$$a + (b + c) = (a + b) + c$$

versus

Verify the following property by replacing the variables with numbers:

$$a + (b + c) = (a + b) + c$$

On the other hand, two different examples may have the same instructions but require you to do different things. For example,

Evaluate: $2(3 - 8)$ versus Evaluate: $2(3)(-8)$

You are asked to evaluate both expressions, but the solutions require different steps.

It is a good idea to familiarize yourself with the various ways the same basic instructions can be worded. In any case, always look at an example carefully and ask yourself what is being asked and what needs to be done, *before you do it.*

Estimation

As you work out exercises and solve problems, it is very important to be constantly aware of the reasonableness of your answer so that you do not propose impossible solutions to problems. This is particularly true when solving verbal problems. While it is obvious that if in a certain problem, x represents the number of 25-pound boxes, then an answer of $x = -7$ is ridiculous, it is also unreasonable to get an answer of $x = 8.3$. Why?

Sometimes recognizing an impossible answer is more subtle. For example, if a total of \$5,000 is split into two investments and x represents one of the investments, then $x =$ \$6,500 is impossible. Why?

Sometimes students are lulled into a false sense of security when they use a calculator to do computations. While it is true that the calculator does not make computational mistakes, you need to be sure that you have chosen to do the correct computations. Additionally, you may inadvertently hit the wrong operations key or put a decimal point in the wrong place. Having an estimate of the correct answer will make it much easier to recognize these types of errors.

Contents

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