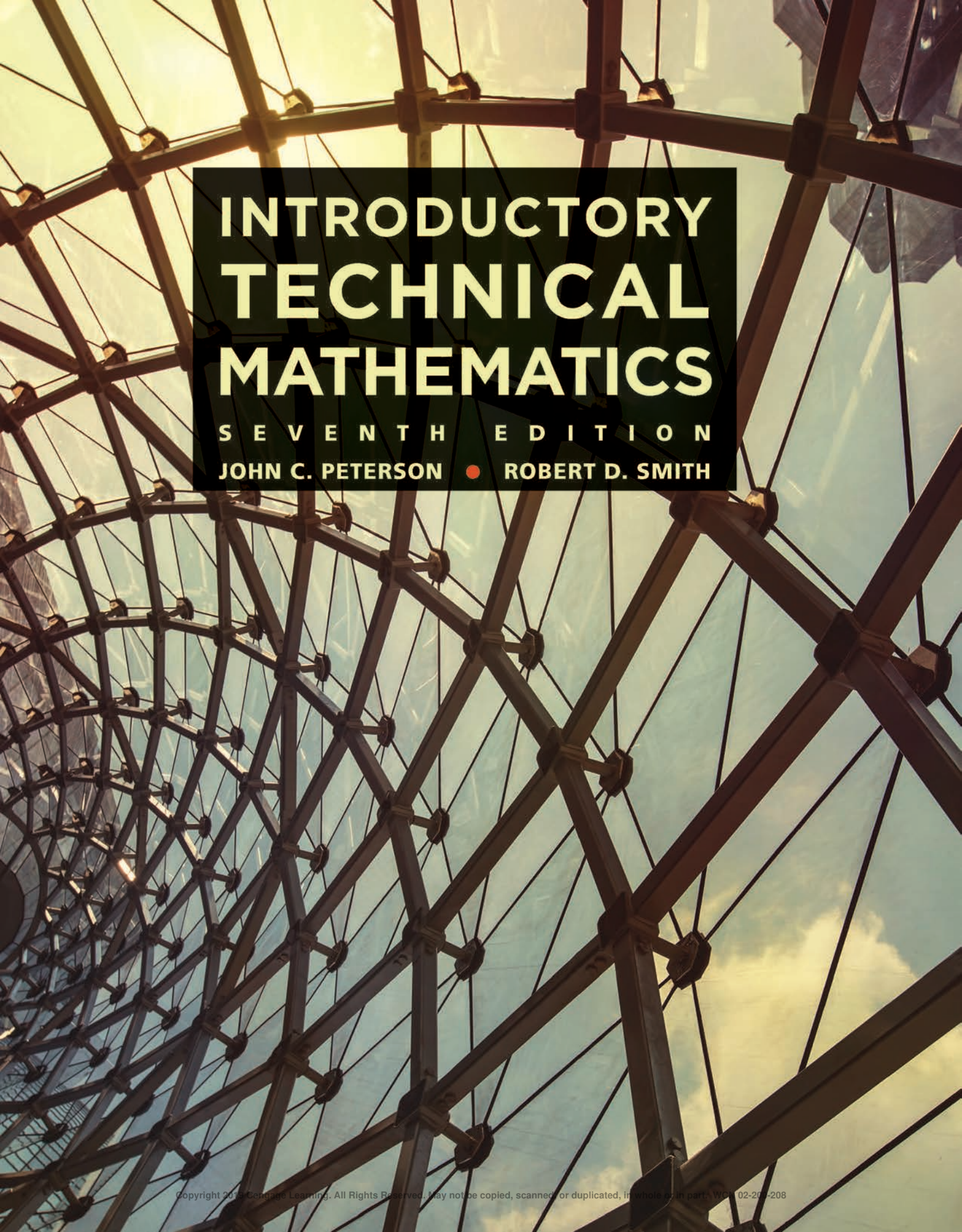

INTRODUCTORY TECHNICAL MATHEMATICS

SEVENTH EDITION

JOHN C. PETERSON • ROBERT D. SMITH

Introductory

Technical Mathematics

7th Edition

John C. Peterson
Robert D. Smith

CENGAGE

Australia • Brazil • Mexico • Singapore • United Kingdom • United States

Introductory Technical Mathematics, 7th edition
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PREFACE

Introductory Technical Mathematics, Seventh Edition, provides practical vocational and technical applications of mathematical concepts. Presentation of concepts is followed by applied examples and problems that have been drawn from diverse occupational fields.

Both content and method have been used by the authors in teaching related technical mathematics on both the secondary and postsecondary levels. Each unit is developed as a learning experience based on preceding units. The applied examples and problems progress from simple to those whose solutions are relatively complex. Many problems require the student to work with illustrations such as are found in trade and technical manuals, handbooks, and drawings.

Students often ask, "Why do we have to learn this material, and of what practical value is it?" This question was constantly kept in mind in writing the book, and every effort was made to continuously provide an answer. The book was written from material developed for classroom use, and it is designed for classroom purposes. However, the text is also very appropriate for self-instruction use. Great care has been taken in presenting explanations clearly and in giving easy-to-follow procedural steps in solving examples. One or more examples are given for each mathematical concept presented. Throughout the book, practical application examples from various occupations are shown to illustrate the actual on-the-job uses of the mathematical concept.

Organization and Approach

An understanding of mathematical concepts is emphasized in all topics. Much effort was made to avoid the mechanical *plug-in* approach often found in mathematics textbooks. A practical rather than an academic approach to mathematics is taken. Derivations and formal proofs are not presented; instead, understanding of concepts followed by the application of concepts in real situations is stressed.

Student exercises and applied problems immediately follow the presentation of concept and examples. Exercises and occupationally related problems are included at the end of each unit. The book contains a sufficient number of exercises and problems to permit the instructor to selectively plan assignments.

Illustrations, examples, exercises, and practical problems expressed in metric units of measure are a basic part of the content of the entire text. Emphasis is placed on the ability of the student to think and to work with equal ease with both the customary and the metric systems.

An analytical approach to problem solving is emphasized in the geometry and trigonometry sections. The approach is that which is used in actual on-the-job trade and technical occupation applications. Integration of algebraic and geometric principles with

trigonometry by careful sequencing and treatment of material also helps the student in solving occupationally related problems.

The majority of instructors state that their students are required to perform basic arithmetic operations on whole numbers, fractions, and decimals prior to calculator or spreadsheet usage. Thereafter, the students use a calculator or spreadsheet almost exclusively in problem-solving computations. The structuring of calculator and spreadsheet instructions and examples in this text reflect the instructors' preferences. The scientific calculator is introduced at the end of this Preface. Extensive calculator instruction and examples are given directly following each of the units on whole numbers, fractions and mixed numbers, and decimals. Further calculator instruction and examples are given throughout the text wherever calculator applications are appropriate to the material presented. Often there are differences in the methods of computation among various makes and models of calculators. Where there are two basic ways of performing calculations, both ways are shown.

Changes to the Seventh Edition

A survey of instructors using the sixth edition was conducted. Based on instructor comments and suggestions, significant changes were made. The result is an updated and improved seventh edition, which includes the following revisions:

- Most exercise sets begin with "Power Up" exercises to help students retain and build skill sets. Technicians often have to power up their equipment when they begin a task. In much the same way, "Power Up" exercises refresh the math concepts students learned in earlier sections. Six to eight "Power Up" exercises appear in most sections except for the Achievement Review sections at the end of each unit.
- More than 1,500 new exercises are included in this edition.
- All electrical applications have been updated to reflect more energy-efficient examples.
- All spreadsheet instructions have been updated to reflect current versions. In particular, emphasis was given to using a spreadsheet on a tablet.
- Estimation usage is expanded throughout the text, so that students have a better realization of when an answer is or is not reasonable.
- Many short sections are combined so the text is more cohesive.

Help for Teaching and Learning

The supplements package has been thoroughly revised and expanded for the seventh edition, offering instructors an array of products that allow them to tailor a course to their own student profile. These supplements are included on the Instructor Companion Website and in the *MindTap for Introductory Technical Mathematics*.

The Instructor Companion Website

The Instructor Companion Website contains the four major items listed below:

Solutions Manual containing fully worked solutions to all the exercises in the text. It is in pdf format so that it can be downloaded to your computer or printed.

Cengage Learning Testing Powered by Cognero is a flexible, online system that allows you to:

- author, edit, and manage test bank content from multiple Cengage Learning solutions.
- create multiple test versions in an instant.
- deliver tests from your LMS, your classroom or wherever you want.

The testbank includes 25 questions per unit, giving the instructor hundreds of questions to choose from throughout the course.

PowerPoint™ presentations of major concepts in the text. These can be downloaded and used in the classroom.

Image Gallery containing most of the figures in the text. Instructors can select the ones they want and either print them for student use or project them.

MindTap for Introductory Technical Mathematics, 7th edition

MindTap for Introductory Technical Mathematics provides a customized learning experience with relevant assignments that will help students learn and apply concepts while it allows instructors to measure skills and outcomes with ease.

MindTap for Introductory Technical Mathematics meets the needs of today's applied math classroom and student. Within the MindTap, faculty and students will find a variety of engaging activities including PowerPoint presentations, videos, whiteboards, and gradable assessments.

About the Authors

John C. Peterson is a retired Professor of Mathematics at Chattanooga State Technical Community College, Chattanooga, Tennessee. Before he began teaching, he worked in the manufacturing industry. He has taught at the middle school, high school, two-year college, and university levels. Dr. Peterson is the author or coauthor of four other Cengage Learning books: *Technical Mathematics*, *Technical Mathematics with Calculus*, *Mathematics for Machine Technology*, and *Math for the Automotive Trade*. He was a member of the four-person team that revised and interpreted the two-year college portion of the 2015 College Board of Mathematical Sciences cross-sectional survey of undergraduate mathematical science programs. In addition, he has had over 90 papers published in various journals, has given over 200 presentations, and has served as a vice president of The American Mathematical Association of Two-Year Colleges.

Robert D. Smith was Associate Professor Emeritus of Industrial Technology at Central Connecticut State University, New Britain, Connecticut. Mr. Smith has had experience in the manufacturing industry as tool designer, quality control engineer, and chief manufacturing engineer. He has also been active in teaching applied mathematics, physics, and industrial materials and processes on the secondary school level and in apprenticeship programs. He is the author of Cengage Learning's *Mathematics for Machine Technology*.

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Introduction to the Scientific Calculator

A scientific calculator is to be used in conjunction with the material presented in this textbook. Complex mathematical calculations can be made quickly, accurately, and easily with a scientific calculator.

Although most functions are performed in the same way, there are some differences among different makes and models of scientific calculators. In this book, generally, where there are two basic ways of performing a function, both ways are shown. However, not all of the differences among the various makes and models of calculators can be shown. It is very important that you become familiar with the operation of your scientific calculator. An owner's manual or reference guide included with the purchase of a scientific calculator explains the essential features and keys of the specific calculator, as well as providing detailed information on the proper use. *It is essential that the owner's manual be studied and referred to whenever there is a question regarding calculator usage.*

For use with this textbook, the most important feature of the scientific calculator is the Algebraic Operating System (AOS™). This system, which uses algebraic logic, permits you to enter numbers and combined operations into the calculator in the same order as the expressions are written. The calculator performs combined operations according to the rules of algebraic logic, which assigns priorities to the various mathematical operations. *It is essential that you know if your calculator uses algebraic logic.*

Most scientific calculators, in addition to the basic arithmetic functions, have algebraic, statistical, conversion, and program or memory functions. Some of the keys with

their functions are shown in the following table. Most scientific calculators have functions in addition to those shown in the table.

Some Typical Key Symbols and Functions for a Scientific Calculator	
Keys	**Functions**
[+], [−], [×], [÷], [=], or [EXE], or [ENTER]	Basic Arithmetic
[+/−] or [(−)]	Change Sign
[π]	Pi
[(], [)]	Parentheses
[EE] or [EXP]	Scientific Notation
[Eng]	Engineering Notation
[STO], [RCL], [EXC]	Memory or Memories
[x^2], [$\sqrt{x}$]	Square and Square Root
[$\sqrt[x]{y}$], [$\sqrt[x]{\ }$]	Root
[y^x] or [x^y]	Power
[$1/x$] or [x^{-1}]	Reciprocal
[%]	Percent
[a b/c] or [A b/c]	Fractions and Mixed Numbers
[DRG]	Degrees, Radians, and Graduations
[DMS] or [° ′ ″]	Degrees, Minutes, and Seconds
[sin], [cos], [tan]	Trigonometric Functions

General Information About the Scientific Calculator

Since there is some variation among different makes and models of scientific calculators, your calculator function keys may be different from the descriptions that follow. *To repeat, it is very important that you refer to the owner's manual whenever there is a question regarding calculator usage.*

- Solutions to combined operations shown in this text are performed on a calculator with algebraic logic (AOS™).

Turning the Calculator On and Off

- The method of turning on a battery-powered calculators depends on the calculator make and model. When a calculator is turned on, 0 and/or other indicators are displayed. Basically, a calculator is turned on and off by one of the following ways.
  - With calculators with an on/clear, [ON/C], key, press [ON/C] to turn on. Press the [OFF] key to turn off.
  - With calculators with an all clear power on/power off, [AC], key, press [AC] to turn on. Generally, the [AC] key is also pressed to turn off.
  - With calculators that have an on-off switch, move the switch either on or off. The switch is usually located on the left side of the calculator.

NOTE: *In order to conserve power, most calculators have a power-off feature that automatically switches off the power after approximately five minutes of nonuse.*

Clearing the Calculator Display and All Pending Operations

- To clear or erase *all* entries of previous calculations, depending on the calculator, either of the following procedures is used.
  - With calculators with an on/clear, ON/C, key, press ON/C *twice*.
  - With calculators with the all clear, AC, key, press AC.

Erasing (Deleting) the Last Calculator Entry

- A last entry error can be removed and corrected without erasing previously entered data and calculations. Depending on the calculator, any of the following procedures are used.
  - With calculators with the on/clear, ON/C, key, press ON/C.
  - With calculators with a delete, DEL, key, press DEL. If your calculator has a back arrow, ◄, key, use it to move the cursor to the part you want to delete.
  - With calculators with a clear, CLEAR, key, press CLEAR.

Alternate–Function Keys

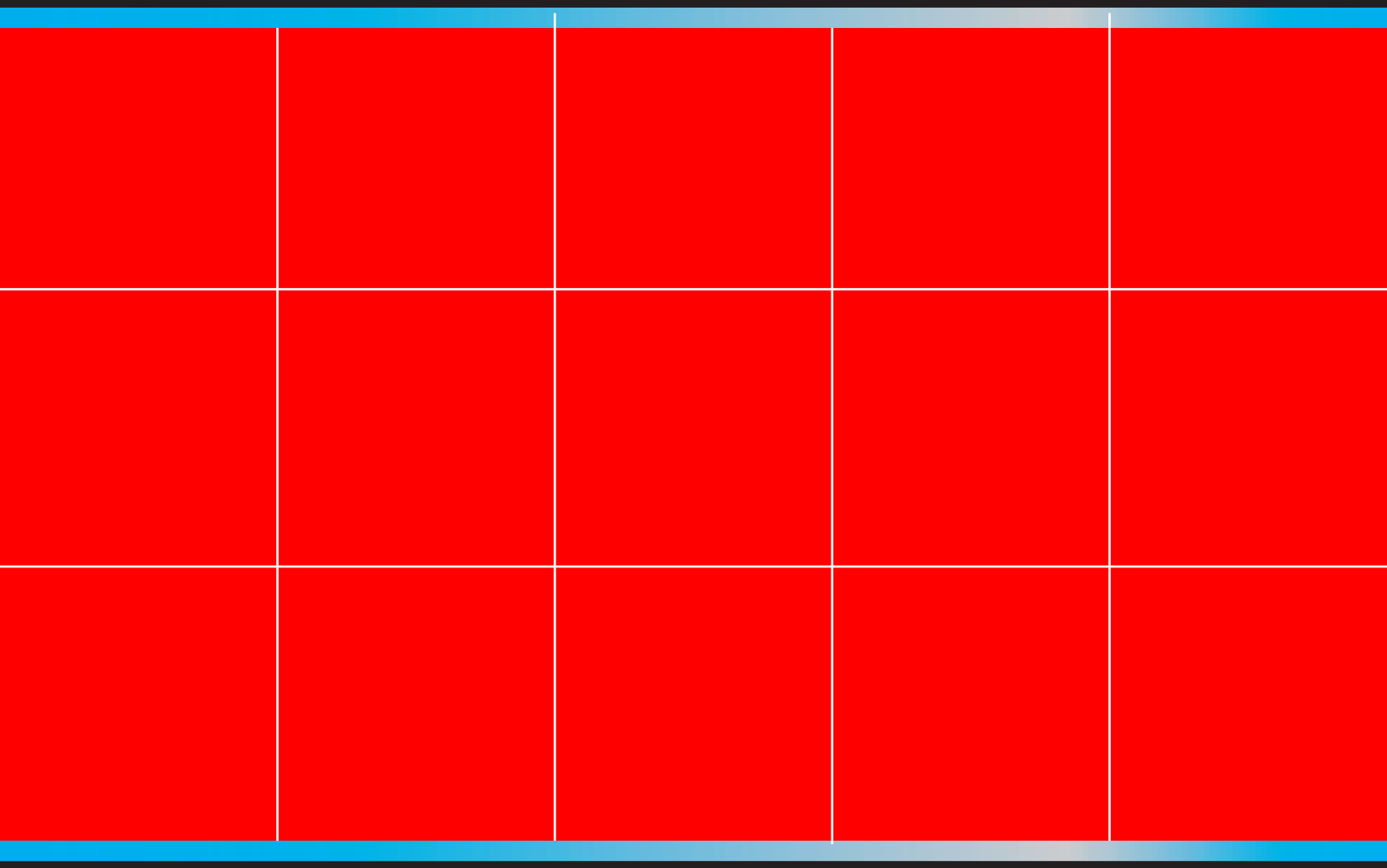
- Most scientific calculator keys can perform more than one function. Depending on the calculator, the 2nd and 3rd keys or the SHIFT key enables you to use alternate functions. The alternate functions are marked above the key and/or on the upper half of the key. Alternate functions are shown and explained in the book where their applications are appropriate to specific content.

Decisions Regarding Calculator Use

The exercises and problems presented throughout the text are well suited for solutions by calculator. However, it is felt decisions regarding calculator usage should be left to the discretion of the course classroom or shop instructor. The instructor best knows the unique learning environment and objectives to be achieved by the students in a course. Judgments should be made by the instructor as to the degree of emphasis to be placed on calculator applications, when and where a calculator is to be used, and the selection of specific problems for solution by calculator. Therefore, exercises and problems in this text are *not* specifically identified as calculator applications.

Calculator instruction and examples of the basic operations of addition, subtraction, multiplication, and division of whole numbers, fractions, and decimals are presented at the ends of each of Units 1, 2, and 3. Further calculator instruction and examples of mathematics operations and functions are given throughout the text wherever calculator applications are appropriate to the material presented.

SECTION I



Fundamentals of General Mathematics

UNIT 1 WHOLE NUMBERS

OBJECTIVES

After studying this unit you should be able to

- express the digit place values of whole numbers.
- write whole numbers in expanded form.
- estimate answers.
- arrange, add, subtract, multiply, and divide whole numbers.
- solve practical problems using addition, subtraction, multiplication, and division of whole numbers.
- solve problems by combining addition, subtraction, multiplication, and division.
- solve arithmetic expressions by applying the proper order of operations.
- solve problems with formulas by applying the proper order of operations.

All occupations, from the least to the most highly skilled, require the use of mathematics. The basic operations of mathematics are addition, subtraction, multiplication, and division. These operations are based on the decimal system. Therefore, it is important that you understand the structure of the decimal system before doing the basic operations.

The development of the decimal system can be traced back many centuries. In ancient times, small numbers were counted by comparing the number of objects with the number of fingers. To count larger numbers pebbles might be used. One pebble represented one counted object. Counting could be done more quickly when the pebbles were placed in groups, generally ten pebbles in each group. Our present number system, the decimal system, is based on this ancient practice of grouping by ten.

1–1 PLACE VALUE

In the decimal system, 10 number symbols or digits are used. The digits 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9 can be arranged to represent any number. The value expressed by each digit depends on its position in the written number. This value is called the **place value**. The chart shows the place value for each digit in the number 2,452,678,932. The digit on the far right is in the units (ones) place. The digit second from the right is in the tens place. The digit third from the right is in the hundreds place. The value of each place is ten times the value of the place directly to its right.

Billions	Hundred Millions	Ten Millions	Millions	Hundred Thousands	Ten Thousands	Thousands	Hundreds	Tens	Units
2	4	5	2	6	7	8	9	3	2

EXAMPLES

Write the place value of the underlined digit in each number.

1. 23,<u>1</u>64 Hundreds ANS
2. 52<u>3</u> Units ANS
3. <u>1</u>43,892 Hundred Thousands ANS
4. 8<u>9</u>,874,726 Millions ANS
5. 76<u>2</u>3 Tens ANS

1–2 EXPANDING WHOLE NUMBERS

The number 64 is a simplified and convenient way of writing 6 tens plus 4 ones. One of the expanded forms of 64 is $(6 \times 10) + (4 \times 1)$.

EXAMPLE

Write the number 382 in expanded form in two different ways.

382 = 3 hundreds plus 8 tens plus 2 ones

382 = 3 hundreds + 8 tens + 2 ones ANS

382 = $(3 \times 100) + (8 \times 10) + (2 \times 1)$ ANS

EXAMPLES

Write each number in expanded form.

1. 7028 $(7 \times 1000) + (0 \times 100) + (2 \times 10) + (8 \times 1)$ ANS
2. 52 5 tens + 2 ones ANS
3. 734 7 hundreds + 3 tens + 4 ones ANS
4. 86,279 $(8 \times 10{,}000) + (6 \times 1000) + (2 \times 100) + (7 \times 10) + (9 \times 1)$ ANS
5. 345 $(3 \times 100) + (4 \times 10) + (5 \times 1)$ ANS

EXERCISE 1–2

Write the place value for the specified digit of each number given in the tables.

	Digit	Number	Place Value
1.	7	6732	HUNDREDS ANS
2.	3	139	
3.	6	16,137	
4.	4	3924	
5.	3	136,805	
6.	2	427	
7.	9	9,732,500	
8.	5	4,578,190	

	Digit	Number	Place Value
9.	1	10,070	
10.	0	15,018	
11.	9	98	
12.	7	782,944	
13.	5	153,400	
14.	9	98,600,057	
15.	2	378,072	
16.	4	43,728	

Write each whole number in expanded form.

17. 857 = $(8 \times 100) + (5 \times 10) + (7 \times 1)$ ANS
18. 32
19. 942
20. 1372
21. 10
22. 5047
23. 379
24. 23,813
25. 504
26. 6376
27. 333
28. 59
29. 600
30. 685,412
31. 90,507
32. 7,500,000
33. 97,560
34. 70,001
35. 234,123
36. 17,643,000
37. 428,000,975

1–3 ESTIMATING (APPROXIMATING AND ROUNDING NUMBERS)

For many on-the-job applications, there are times when an exact mathematical answer is not required. Often a rough mental calculation is all that is needed. Making a rough calculation is called estimating or approximating. Estimating is widely used in practical applications. A painter estimates the number of gallons of paint needed to paint the exterior of a building; it would not be practical to compute the paint requirement to a fraction of a gallon. In ordering plywood for a job, a carpenter makes a rough calculation of the number of sheets required. An electrician approximates the number of feet of electrical cable needed for a wiring job; there is no need to calculate the exact length of cable.

When computing an exact answer, it is also essential to estimate the answer before the actual arithmetic computations are made. Mistakes often can be avoided if approximate values of answers are compared with their computed values. For example, if digits are incorrectly aligned when doing an arithmetic operation, errors of magnitude are made. Answers that are $\frac{1}{10}$ or 10 times the value of what the answer should be are sometimes carelessly made. First estimate the answer and check it by comparing it with the computed answer. This will tell you if an error of this type has been made.

Examples of estimating answers are given in this unit. When solving exercises and problems in this unit, estimate answers and compare the computed answers against the estimated answers. Continue to estimate answers for exercises and problems throughout the book.

It is important also to estimate answers when using a calculator. You can press the wrong digit or the wrong operation sign; you can forget to enter a number. If you have approximated an answer and check it against the calculated answer, you will know if you have made a serious mistake.

When estimating an answer, exact values are rounded. Rounded values are approximate values. **Rounding numbers** enables you to mentally perform arithmetic operations. When rounding whole numbers, determine the place value to which the number is to be rounded. Increase the digit at the place value by 1 if the digit that follows is 5 or more. Do not change the digit at the place value if the digit that follows is less than 5. Replace all the digits to the right of the digit at the place value with zeros.

EXAMPLES

1. Round 612 to the nearest hundred.
   Look at the digit in the tens place, 1.
   Since 1 is less than 5, 6 remains unchanged. 600 ANS
2. Round 873 to the nearest hundred.
   Look at the digit in the tens place, 7.
   Since 7 is greater than 5, change 8 to 9. 900 ANS
3. Round 4216 to the nearest thousand.
   The number in the hundreds place is 2.
   Since 2 is less than 5, 4 remains unchanged. 4000 ANS
4. Round 175,890 to the nearest ten thousand.
   The number in the thousands place is 5.
   Change the 7 to 8. 180,000 ANS

EXERCISE 1–3A

Round the following numbers as indicated.

1. 63 to the nearest ten
2. 540 to the nearest hundred
3. 766 to the nearest hundred
4. 2587 to the nearest thousand
5. 8480 to the nearest thousand
6. 32,403 to the nearest ten thousand

7. 46,820 to the nearest thousand
8. 53,738 to the nearest ten thousand
9. 466,973 to the nearest ten thousand
10. 949,500 to the nearest hundred thousand

Rounding to the Even

Many technical trades use a process called **rounding to the even**. Rounding to the even can be used to help reduce bias when several numbers are added. When using rounding to the even, determine the place value to which the number is to be rounded. (This is the same as in the previous method.) The only change is when the digit that follows is a 5 followed by all zeros. Then increase the digits at the place value by 1 if it is an odd number (1, 3, 5, 7, or 9). Do not change it if it is an even number (0, 2, 4, 6, or 8). In both cases, replace the 5 with a 0.

EXAMPLES

1. Round 4250 to the nearest hundred.
   Since 2 is an even number, it remains the same. 4200 ANS
2. Round 673,500 to the nearest thousand.
   Since 3 is an odd number, change the 3 to a 4. 674,000 ANS

EXERCISE 1–3B Use rounding to the even to round the following numbers as indicated.

1. 785 to the nearest ten
2. 675 to the nearest ten
3. 1350 to the nearest hundred
4. 5450 to the nearest hundred
5. 31,500 to the nearest thousand
6. 24,520 to the nearest thousand
7. 26,455 to the nearest hundred
8. 26,455 to the nearest ten

1–4 ADDITION OF WHOLE NUMBERS

A contractor determines the cost of materials in a building. A salesperson charges a customer for the total cost of a number of purchases. An air-conditioning and refrigeration technician finds lengths of duct needed. These people are using addition. Practically every occupation requires daily use of addition.

Definitions and Properties of Addition

The result of adding numbers (the answer) is called the **sum**. The **plus sign** (+) indicates addition.

Numbers can be added in any order. The same sum is obtained regardless of the order in which the numbers are added. This is called the **commutative property of addition**. For example, $2 + 4 + 3$ may be added in either of the following ways:

$$2 + 4 + 3 = 9 \quad \text{or} \quad 3 + 4 + 2 = 9$$

The numbers can also be grouped in any way and the sum is the same. This is called the **associative property of addition**. (The numbers inside parentheses are added first.)

$$(2 + 4) + 3 \qquad \text{or} \qquad 2 + (4 + 3)$$
$$6 + 3 = 9 \qquad\qquad 2 + 7 = 9$$

Procedure for Adding Whole Numbers

Writing the numbers in expanded form shows why the numbers are lined up in the short form as described below.

EXAMPLE

Add. 345 + 613

EXPANDED FORM					SHORT FORM
3 hundreds	+	4 tens	+	5 ones	345
6 hundreds	+	1 ten	+	3 ones	+613
9 hundreds	+	5 tens	+	8 ones	958
↑		↑		↑	
add hundreds		add tens		add ones	

In the short form, write the numbers to be added under each other. Place the units digits under the units digit, the tens digits under the tens digit, etc. Add each column of numbers starting from the column on the right (units column). If the sum of any column is ten or more, write the last digit of the sum in the answer. Mentally add the rest of the number to the next column. Continue the same procedure until all columns are added.

EXAMPLES

1. Add. 763 + 619

   Estimate the answer. Round each number to the nearest hundred.

   800 + 600 = 1400

   Compute the answer.

   Write the numbers under each other, placing digits in proper place positions.
   Add the numbers in the units column: 3 + 9 = 12.
   Write 2 in the answer.
   Add the 1 to the numbers in the tens column: (1) + 6 + 1 = 8.
   Add the numbers in the hundreds column: 7 + 6 = 13.
   Write 13 in the answer.

   ```
     7 6 3
   + 6 1 9
   -------
   1 3 8 2  ANS
   ```

   Compare. The exact answer 1382 is approximately the same as the estimate 1400.

2. Add. 63,679 + 227 + 8125 + 96

   Estimate the answer. Round each number to the nearest thousand.

   64,000 + 0 + 8000 + 0 = 72,000

   Compute the answer.

   Compare to check. The exact answer is 72,127. It is approximately the same as the estimate of 72,000.

   ```
     6 3 6 7 9
         2 2 7
       8 1 2 5
   +         9 6
   -----------
     7 2 1 2 7  ANS
   ```

EXERCISE 1–4 POWER UP

These Power Up exercises review concepts that you studied earlier. Use them to refresh your skills before you attempt this exercise set.

Write the place value for the underlined digit in problems 1 and 2.

1. 5391
2. 12,673

Write each number in problems 3 and 4 in expanded form in two different ways.

3. 485
4. 2791

Round each number in problems 5 and 6 as indicated.

5. 3942 (to the nearest ten)
6. 51,752 (nearest hundred)

ESTIMATING SUMS

Estimate each of the following sums to the indicated place value.

7. 33 + 88 (nearest ten)
8. 953 + 38 (nearest ten)
9. 53 + 12 + 951 (nearest ten)
10. 896 + 675 + 33 (nearest hundred)
11. 73 + 1370 + 542 (nearest hundred)
12. 3653 + 8063 + 47 (nearest hundred)
13. 6737 + 3519 + 8180 (nearest thousand)
14. 9734 + 10,505 + 91,613 (nearest thousand)
15. 15,973 + 829 + 7515 (nearest thousand)
16. 17,392 + 2085 + 1670 + 13 (nearest thousand)

ADDING WHOLE NUMBERS

Add the following numbers. In problems 17 through 26, compare your answers with your estimates in problems 7 through 16.

17. 33 + 88
18. 953 + 38
19. 53 + 12 + 951
20. 896 + 675 + 33
21. 73 + 1370 + 542
22. 3653 + 8063 + 47
23. 6737 + 3519 + 8180
24. 9734 + 10,505 + 91,613
25. 15,973 + 829 + 7515
26. 17,392 + 2085 + 1670 + 13
27. 38 + 55,404 + 132,997 + 8
28. 18,768 + 3023 + 7,787,030 + 544

1–5 SUBTRACTION OF WHOLE NUMBERS

A plumber uses subtraction to compute material requirements of a job. A machinist determines locations of holes to be drilled. A retail clerk inventories merchandise. An electrician estimates the profit of a wiring installation. Subtraction has many on-the-job applications.

Definitions

Subtraction is the operation that determines the difference between two quantities. It is the **inverse** or opposite of addition. The quantity subtracted is called the **subtrahend**. The quantity from which the subtrahend is subtracted is called the **minuend**. The result of the subtraction operation is called the **difference**. The **minus sign** (−) indicates subtraction.

Procedure for Subtracting Whole Numbers

Write the number to be subtracted (subtrahend) under the number from which it is subtracted (minuend). Place the units digit under the units digit, the tens digit under the tens digit, etc. Subtract each column of numbers starting from the right (units column). Writing the numbers in expanded form shows why the numbers are lined up when they are subtracted.

EXAMPLE

Subtract. 847 − 315

EXPANDED FORM					SHORT FORM
8 hundreds	+	4 tens	+	7 ones	847
3 hundreds	+	1 ten	+	5 ones	−315
5 hundreds	+	3 tens	+	2 ones	532 ANS
↑		↑		↑	
subtract hundreds		subtract tens		subtract ones	

If the digit in the subtrahend represents a value greater than the value of the corresponding digit in the minuend, it is necessary to regroup. Regroup the number in the minuend by taking or borrowing 1 from the number in the next higher place and adding 10 to the number in the place directly to the right. The value of the minuend remains unchanged. The value represented by each digit of a number is 10 times the value represented by the digit directly to its right. For example, 85 is a convenient way of writing 8 tens plus 5 ones, $(8 \times 10) + (5 \times 1)$. The 5 in 85 can be increased to 15 by taking 1 from the 8 without changing the value of 85. This process is called **regrouping**, or **borrowing**, since 8 tens and 5 units $(80 + 5)$ is regrouped as 7 tens and 15 units $(70 + 15)$.

EXAMPLE

Subtract. 739 − 462

EXPANDED FORM				
7 hundreds	+	3 tens	+	9 ones
4 hundreds	+	6 tens	+	2 ones

REGROUPED FORM					SHORT FORM
6 hundreds	+	13 tens	+	9 ones	$6^{1}39$
4 hundreds	+	6 tens	+	2 ones	4 62
2 hundreds	+	7 tens	+	7 ones	2 77 ANS

The difference can be checked by adding the difference to the subtrahend. The sum should equal the minuend. If the sum does not equal the minuend, go over the operation to find the error.

EXAMPLES

1. Subtract. 917 − 523

   Estimate the answer. Round each number to the nearest hundred.

   900 − 500 = 400

   Compute the answer.

   Write the subtrahend 523 under the minuend 917. Place the digits in the proper place positions.

   Subtract the units: 7 − 3 = 4. Write 4 in the answer.

   Subtract the tens. Since 2 is larger than 1, regroup the minuend 917.

   $(8 \times 100) + (11 \times 10) + (7 \times 1)$

9	1	7
− 5	2	3
3	9	4 ANS

11 − 2 = 9. Write 9 in the answer.

Subtract the hundreds: 8 − 5 = 3. Write 3 in the answer.

Check the answer to the estimate.

394 is approximately the same as 400.

Check by adding. Adding the answer 394 and the subtrahend 523 equals the minuend 917.

$$\begin{array}{r} 3\ 9\ 4 \\ +\,5\ 2\ 3 \\ \hline 9\ 1\ 7 \end{array}$$ Ck

2. Subtract. 87,126 − 3874

Estimate the answer. Round each number to the nearest thousand.

87,000 − 4000 = 83,000

Compute the answer.

$$\begin{array}{r} 8\ 7\,1\ 2\ 6 \\ -\quad 3\ 8\ 7\ 4 \\ \hline 8\ 3\ 2\ 5\ 2 \end{array}$$ Ans

Check the answer to the estimate. 83,252 is approximately the same as 83,000.

Check by adding. Adding the answer 83,252 and the subtrahend 3874 equals the minuend 87,126.

$$\begin{array}{r} 8\ 3\ 2\ 5\ 2 \\ +\quad 3\ 8\ 7\ 4 \\ \hline 8\ 7\ 1\ 2\ 6 \end{array}$$ Ck

EXERCISE 1–5 POWERUP

These Power Up exercises review concepts that you studied earlier. Use them to refresh your skills before you attempt this exercise set.

Round the numbers in problems 1 and 2 as indicated.

1. 13,456 to the nearest hundred
2. 932,641 to the nearest thousand

Estimate each of the sums in problems 3 and 4 to the indicated place value.

3. 48 + 163 (nearest ten)
4. 562 + 739 (nearest hundred)

Find the sums in problems 5 and 6. Compare your answers with your estimates in problems 3 and 4.

5. 48 + 163
6. 562 + 739

ESTIMATING DIFFERENCES

Estimate each of the differences in problems 7 through 16 to the indicated place value.

7. 35 − 18 (nearest ten)
8. 98 − 29 (nearest ten)
9. 76 − 67 (nearest ten)
10. 312 − 97 (nearest ten)
11. 673 − 558 (nearest hundred)
12. 1570 − 988 (nearest hundred)
13. 7803 − 5905 (nearest hundred)
14. 49,406 − 5498 (nearest thousand)
15. 19,135 − 11,236 (nearest thousand)
16. 707,335 − 533,974 (nearest ten thousand)

SUBTRACTING WHOLE NUMBERS

Subtract the following numbers. In problems 17 through 26, compare your answers with your estimates in problems 7 through 16.

17. 35 − 18
18. 98 − 29
19. 76 − 67
20. 312 − 97
21. 673 − 558
22. 1570 − 988

23. 7803 − 5905
24. 49,406 − 5498
25. 19,135 − 11,236
26. 707,335 − 533,974

Use the chart shown in Figure 1–1 for problems 27 through 32. Find how much greater value A is than value B.

	A	B	Estimated Difference	Actual Difference
27.	517 inches	298 inches		
28.	779 meters	488 meters		
29.	2732 pounds	976 pounds		
30.	8700 days	5555 days		
31.	12 807 liters	9858 liters		
32.	4464 acres	1937 acres		

FIGURE 1–1

COMBINING ADDITION AND SUBTRACTION OF WHOLE NUMBERS

Solve and check. The addition in parentheses is done first.

33. 87 − (35 + 19) = 33 ANS
34. 908 − (312 + 6 + 88)
35. 3987 − (616 + 17 + 1306)
36. (32 + 63 + 9) − 22
37. (503 + 7877 + 6) − 2033
38. (473 + 197 + 42) − 514

1–6 PROBLEM SOLVING—WORD PROBLEM PRACTICAL APPLICATIONS

It is important that you have the ability to solve problems that are given as statements, commonly called word problems. In actual practice, situations or problems have to be "figured out." Often, the relevant facts of the problem are written down and analyzed. The procedure for solving a problem is determined before arithmetic computations are made.

Whether the word problem is simple or complex, a definite logical procedure should be followed to analyze the problem. Some or all of the following steps may be required depending on the nature and complexity of the particular problem.

- Read the entire problem, several times if necessary, until you understand what it states and what it asks.
- Understand each part of the given information. Determine how the given information is related to what is to be found.
- If the problem is complex, break the problem down into simpler parts.
- It is sometimes helpful to make a simple sketch to help visualize the various parts of a problem.
- Estimate the answer.
- Calculate or compute the answer. Write your computations carefully and neatly. Check your work to make sure you have not made a computational error.
- Check the answer step-by-step against the statement of the original problem. Did you answer the question asked? Is the answer close to your estimate? If not, recheck your work.
- Always ask yourself, "Does my answer sound sensible?" If not, recheck your work.

1–7 ADDING AND SUBTRACTING WHOLE NUMBERS IN PRACTICAL APPLICATIONS

EXAMPLE

The production schedule for a manufacturing plant calls for a total of 2370 parts to be completed in 5 weeks. The number of parts manufactured during the first 4 weeks are 382, 417, 485, and 508, respectively. How many parts must be produced in the fifth week to fill the order?

Determine the procedure.

The number of parts produced in the fifth week equals the total parts to be completed minus the sum of 4 weeks' production.

Estimate the answer.

$2400 - (400 + 400 + 500 + 500)$

$2400 - 1800 = 600$

Compute the answer.

$2370 - (382 + 417 + 485 + 508)$

$2370 - 1792 = 578$ 578 parts ANS

Check the answer to the estimate.

578 is approximately the same as 600.

EXERCISE 1–7

POWERUP

These Power Up exercises review concepts that you studied earlier. Use them to refresh your skills before you attempt this exercise set.

Estimate each of the sums in problems 1 and 2 to the indicated place value.

1. 649 + 2374 (nearest hundred)
2. 1291 + 68 (nearest hundred)

Estimate each of the differences in problems 3 through 6 to the indicated place value.

3. 93 − 47 (nearest ten)
4. 207 − 84 (nearest ten)
5. 4238 − 2076 (nearest hundred)
6. 12,516 − 762 (nearest hundred)

WHOLE NUMBER APPLICATIONS WITH ADDITION AND SUBTRACTION

7. A heavy equipment operator contracts to excavate 850 cubic yards of earth for a house foundation. How much remains to be excavated after 585 cubic yards are removed?
8. A sheet metal contractor has 124 feet of band iron in stock. An additional 460 feet are purchased. On June 2, 225 feet are used. On June 4, 197 feet are used. How many feet of band iron are left after June 4?
9. An automobile mechanic determines the total bill for both labor and materials for an engine overhaul at $463. The customer pays $375 by credit card and pays the balance by cash. What amount does the customer pay by cash?
10. An electrical contractor has 5000 meters of bX cable in stock at the beginning of a wiring job. At different times during the job, electricians remove the following lengths from stock: 325 meters, 580 meters, 260 meters, and 65 meters. When the job is completed, 135 meters are left over and are returned to stock. How many meters of cable are now in stock?

11. A painter and decorator purchase 18 gallons of paint and 68 rolls of wallpaper for a house redecorating contract. Figure 1–2 lists the amount of materials that are used in each room.
    a. Find the amount of paint remaining at the end of the job.
    b. Find the amount of wallpaper remaining at the end of the job.

	Kitchen	Living Room	Dining Room	Master Bedroom	Second Bedroom	Third Bedroom
Paint	2 gallons	4 gallons	2 gallons	3 gallons	3 gallons	2 gallons
Wallpaper	8 rolls	14 rolls	10 rolls	12 rolls	10 rolls	9 rolls

FIGURE 1–2

12. Five stamping machines in a manufacturing plant produce the same product. Each machine has a counter that records the number of parts produced. Figure 1–3 shows the counter readings for the beginning and end of one week's production.
    a. How many parts are produced during the week by each machine?
    b. What is the total weekly production?

	Machine 1	Machine 2	Machine 3	Machine 4	Machine 5
Counter Reading Beginning of Week	17,855	13,935	7536	38,935	676
Counter Reading End of Week	48,951	42,007	37,881	72,302	29,275

FIGURE 1–3

13. A printer bills a customer $1575 for an order. In printing the order, expenses are $432 for bond paper, $287 for cover stock, $177 for envelopes, and $26 for miscellaneous materials. The customer pays the bill within 30 days and is allowed a $32 discount. How much profit does the printer make?
14. An electrical contractor uses the following amounts of cable during the first three months of the year: January: 8320 feet; February: 7650 feet; and March: 4972 feet.
    a. Round the amount for each month to the nearest hundred feet and add to find the approximate amount of cable used during these first three months.
    b. Find the actual total amount of cable used during this three-month period.
15. An electrical contractor uses the following amounts of cable during the second quarter of the year: April: 9630 feet; May: 10,286 feet; and June: 12,577 feet.
    a. Round the amount for each month to the nearest hundred feet and add to find the approximate amount of cable used during this quarter.
    b. Find the actual total amount of cable used during this quarter.
16. Figure 1–4 lists various kinds of flour ordered and received by a commercial baker.
    a. Is the total amount of flour received greater or less than the total amount ordered?
    b. How many pounds greater or less?

	Bread Flour	Cake Flour	Rye Flour	Rice Flour	Potato Flour	Soybean Flour
Ordered	3875 lb	2000 lb	825 lb	180 lb	210 lb	85 lb
Received	3650 lb	2670 lb	910 lb	75 lb	165 lb	85 lb

FIGURE 1–4

17. In order to make the jig shown in Figure 1–5, a machinist determines dimensions A, B, C, and D. All dimensions are in millimeters. Find A, B, C, and D in millimeters.

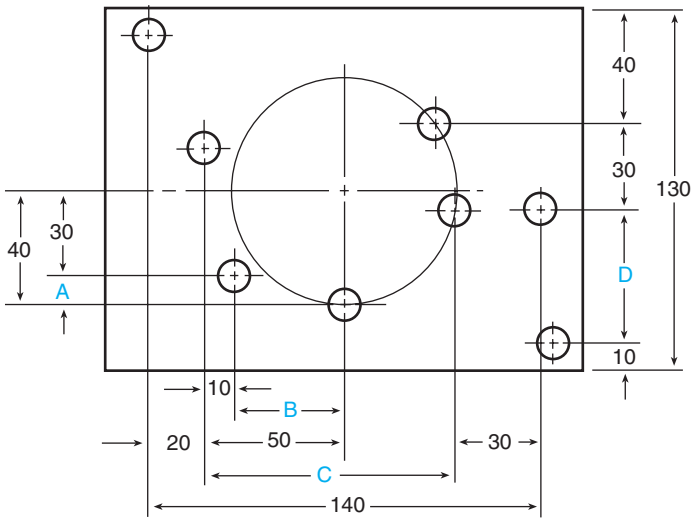


FIGURE 1–5

18. A small business complex is shown in Figure 1–6. To provide parking space, a paving contractor is hired to pave the area not occupied by buildings or covered by landscaped areas. The entire parcel of land contains 41,680 square feet. How many square feet of land are to be paved?

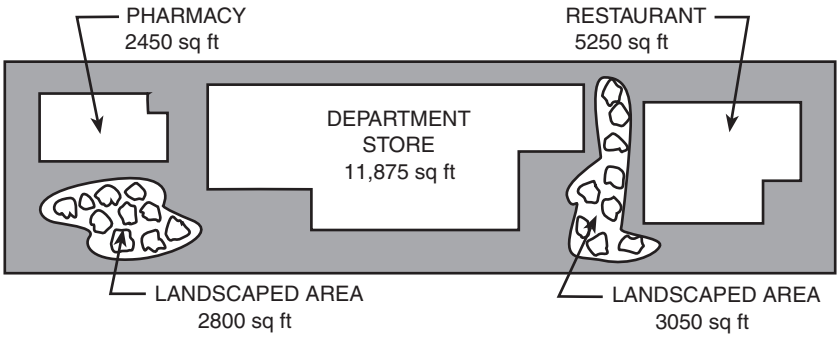


FIGURE 1–6

19. At the beginning of the week, an electrical supply house has 853 solenoids in stock. During the week, the following number of solenoids were sold: Monday: 57; Tuesday: 73; Wednesday: 64; Thursday: 49; and Friday: 62.
    a. Round off the numbers of solenoids sold to the nearest ten and add to determine the approximate number of solenoids sold during the week.
    b. Round off the number of solenoids in stock at the beginning of the week to the nearest ten. Use this number and your answer to (a) to approximate the number of solenoids in stock at the end of the week.
    c. Determine the actual number of solenoids in stock at the end of the week.
20. On a particular job, the contractor's expenses were $794 for material, $537 in carpenter labor, and $486 for taxes and insurance. The contractor is paid $1974.
    a. What was the total of the expenses?
    b. If the profit is the difference between the amount paid and the expenses, what was the profit for this job?

1–8 MULTIPLICATION OF WHOLE NUMBERS

A mason estimates the number of bricks required for a chimney. A clerk in a hardware store computes the cost of a customer's order. A secretary determines the weekly payroll of a firm. A cabinetmaker calculates the amount of plywood needed to install a store counter.

A garment manufacturing supervisor determines the amounts of various materials required for a production run. These are a few of the many occupational uses of multiplication.

Definitions and Properties of Multiplication

Multiplication is a short method of adding equal amounts. For example, 4 times 5 (4×5) means 4 fives or $5 + 5 + 5 + 5$.

The number to be multiplied is called the **multiplicand**. The number by which it is multiplied is called the **multiplier**. The numbers used in multiplying are called **factors**. The multiplicand and the multiplier are both factors. The result or answer of the multiplication is called the **product**. The **times sign** ($\times$) indicates multiplication.

Numbers can be multiplied in any order. The same product is obtained regardless of the order in which the numbers (factors) are multiplied. This is called the **commutative property of multiplication**. For example, $2 \times 4 \times 3$ may be multiplied in either of the following ways:

$$2 \times 4 \times 3 = 24 \qquad \text{or} \qquad 3 \times 4 \times 2 = 24$$

The numbers can also be grouped in any way and the product is the same. This is called the **associative property of multiplication**. (The numbers inside parentheses are multiplied first.)

$$(2 \times 4) \times 3 \qquad \text{or} \qquad 2 \times (4 \times 3)$$
$$8 \times 3 = 24 \qquad\qquad 2 \times 12 = 24$$

Expanded Form of Multiplication

The expanded form for multiplication shows why the products are aligned as described later.

EXAMPLE

Multiply. 386×7

EXPANDED FORM					SHORTER FORM
3 hundreds	+	8 tens	+	6 ones	386
×				7	× 7
21 hundreds	+	56 tens	+	42 ones	42
2100	+	560	+	42	560
2702					2100
					2702

Procedure for Short Multiplication

Short multiplication is used to compute the product of two numbers when the multiplier contains only one digit. A problem such as 7×386 requires short multiplication.

EXAMPLE

Multiply. 7×386

Estimate the answer. Round 386 to 400.

$7 \times 400 = 2800$

Compute the answer.

Write the multiplier under the units digit of the multiplicand.

Multiply the 7 by the units of the multiplicand.

$7 \times 6 = 42$

```
  3 8 6
×     7
2 7 0 2 ANS
```

Write 2 in the units position of the answer.
Multiply the 7 by the tens of the multiplicand.

$7 \times 8 = 56$

Add the 4 tens from the product of the units.

$56 + 4 = 60$

Write the 0 in the tens position of the answer.
Multiply the 7 by the hundreds of the multiplicand.

$7 \times 3 = 21$

Add the 6 hundreds from the product of the tens.

$21 + 6 = 27$

Write the 7 in the hundreds position and the 2 in the thousands position.

Check the answer to the estimate.

2702 is approximately the same as 2800.

Procedure for Long Multiplication

Long multiplication is used to compute the product of two numbers when the multiplier contains two or more digits. A problem such as 436×7812 requires long multiplication.

When multiplying by a number that is not in the ones place, both the digits and the place values get multiplied. For example, 4 tens $\times$ 6 tens = 24 tens $\times$ tens = 24 hundreds.

EXAMPLE

Multiply. 314×72

EXPANDED FORM									SHORTER FORM
		3 hundreds	+	1 ten	+	4 ones			314
				7 tens	+	2 ones			× 72
		6 hundreds	+	2 tens	+	8 ones			8
		600	+	20	+	8			20
21 thousands	+	7 hundreds	+	28 tens	+	0 ones			600
21,000	+	700	+	280		0			280
22,608									700
									21,000
									22,608

EXAMPLE

Multiply. 436×7812

Estimate the answer. Round 436 to 400 and 7812 to 8000.

$400 \times 8000 = 3{,}200{,}000$

Compute the answer.

Write the multiplier under the multiplicand, placing digits in proper place positions.
Multiply the multiplicand by the units of the multiplier, using the procedure for short multiplication. This answer is called the first partial product.

$6 \times 7812 = 46{,}872$

Write the first partial product, starting at the units position and going from right to left.
Multiply the multiplicand by the tens of the multiplier to get the second partial product.

$3 \times 7812 = 23{,}436$

```
   7 8 1 2
 × 4 3 6
 4 6 8 7 2
 2 3 4 3 6
3 1 2 4 8
3 4 0 6 0 3 2 ANS
```

Write this partial product under the first partial product, starting at the tens position and going from right to left.

Multiply the multiplicand by the hundreds of the multiplier for the third, and last, partial product.

$4 \times 7812 = 31{,}248$

Write the last partial product under the second partial product, starting at the hundreds position and going from right to left.

Add the three partial products to get the product.

Check the answer to the estimate.

3,406,032 is approximately the same as 3,200,000.

Multiplication with a Zero in the Multiplier

The product of any number and zero is zero. This is called the **multiplicative property of zero**. For example, $0 \times 0 = 0, 0 \times 6 = 0, 0 \times 8956 = 0$. When the multiplier contains zeros, the zeros must be written in the product to maintain proper place value.

EXAMPLE

Multiply. 243×60

EXPANDED FORM	SHORTER FORM
2 hundreds + 4 tens + 3 ones	243
$\times$ 6 tens + 0	$\times$ 60
0 hundreds + 0 tens + 0 ones	0
12 thousand + 24 hundreds + 18 tens + 0 ones	180
12,000 + 2400 + 180 + 0	2400
14,580	12,000
	14,580

EXAMPLES

1.
$$\begin{array}{r} 674 \\ \times\ 200 \\ \hline 134{,}800 \end{array}$$

2.
$$\begin{array}{r} 364 \\ \times\ 203 \\ \hline 1092 \\ 7280 \\ \hline 73{,}892 \end{array}$$

Multiplying Three or More Factors

As previously stated by the associative property, the multiplication of three or more numbers, two at a time, may be done in any order or in any grouping. The factors are multiplied in separate steps. Two groupings are shown in the following example.

EXAMPLE

$\underbrace{7 \times 5} \times 2 \times 3$

$\underbrace{35 \times 2} \times 3$

$\underbrace{70 \times 3}$

210 ANS

$7 \times 5 \times \underbrace{2 \times 3}$

$7 \times \underbrace{5 \times 6}$

$\underbrace{7 \times 30}$

210 ANS

EXERCISE 1–8 POWERUP

These Power Up exercises review concepts that you studied earlier. Use them to refresh your skills before you attempt this exercise set.

In problems 1 through 4, estimate each sum and then add. Check your answer.

1. 42 + 87
2. 91 + 135
3. 215 + 56 + 391
4. 1273 + 456 + 84

In problems 5 and 6, estimate each difference and then subtract. Check your answer.

5. 321 − 68
6. 565 − 121

ESTIMATING PRODUCTS

Estimate each of the following products.

7. 75 × 8
8. 775 × 5
9. 1877 × 9
10. 54,157 × 8
11. 57 × 81
12. 914 × 67
13. 12,737 × 79
14. 7816 × 513
15. 15,553 × 999
16. 23,418 × 1147

MULTIPLYING WHOLE NUMBERS

Multiply and check. In problems 17 through 20 compare your answers with your estimates in problems 7 through 10, and in problems 27 through 32, check your answers with your estimates in problems 11 through 16.

17. $\begin{array}{r} 75 \\ \times\ 8 \\ \hline \end{array}$
18. $\begin{array}{r} 775 \\ \times\ 5 \\ \hline \end{array}$
19. $\begin{array}{r} 1877 \\ \times\ 9 \\ \hline \end{array}$
20. $\begin{array}{r} 54{,}157 \\ \times\ 8 \\ \hline \end{array}$
21. 6 × 523
22. 3 × 1804
23. 5 × 12,199
24. 4 × 456,900
25. 8 × 318,234
26. 9 × 2,132,512
27. $\begin{array}{r} 57 \\ \times\ 81 \\ \hline \end{array}$
28. $\begin{array}{r} 914 \\ \times\ 67 \\ \hline \end{array}$
29. $\begin{array}{r} 12{,}737 \\ \times\ 79 \\ \hline \end{array}$
30. $\begin{array}{r} 7816 \\ \times\ 513 \\ \hline \end{array}$
31. $\begin{array}{r} 15{,}553 \\ \times\ 999 \\ \hline \end{array}$
32. $\begin{array}{r} 23{,}418 \\ \times\ 1147 \\ \hline \end{array}$
33. $\begin{array}{r} 327{,}800 \\ \times\ 274 \\ \hline \end{array}$
34. $\begin{array}{r} 405{,}607 \\ \times\ 112 \\ \hline \end{array}$
35. 419 × 7635
36. 423 × 63,940
37. 2561 × 17,738
38. 1176 × 62,347
39. 4214 × 18,919
40. $\begin{array}{r} 943 \\ \times\ 70 \\ \hline \end{array}$
41. $\begin{array}{r} 1798 \\ \times\ 507 \\ \hline \end{array}$
42. $\begin{array}{r} 7100 \\ \times\ 590 \\ \hline \end{array}$
43. $\begin{array}{r} 8009 \\ \times\ 400 \\ \hline \end{array}$
44. 6 × 8 × 15
45. 12 × 16 × 7
46. 63 × 150 × 15 × 8

1–9 DIVISION OF WHOLE NUMBERS

Division is used in all occupations. The electrician must know the number of rolls of cable to order for a job. A baker determines the number of finished units made from a batch of dough. A landscaper needs to know the number of bags of lawn food required for a given area of grass. A printer determines the number of reams of paper needed for a production run of circulars.

Division is the process of finding how many times one number is contained in another. It is a short method of subtracting. Dividing 24 by 6 is a way to find the number of times 6 is contained in 24.

$$24 - 6 = 18$$
$$18 - 6 = 12$$
$$12 - 6 = 6$$
$$6 - 6 = 0$$

Six is subtracted 4 times from 24; therefore, 4 sixes are contained in 24.

$$24 \div 6 = 4$$

Definitions

Division is the opposite, or **inverse**, of multiplication. In division, the number to be divided is called the **dividend**. The number by which the dividend is divided is called the **divisor**. The result of division is called the **quotient**. The difference that is left is called the **remainder**. The symbol for division is ÷. The expression $21 \div 7$ can be written in fractional form as $\frac{21}{7}$. When written as a fraction, the dividend, 21, is called the numerator, and the divisor, 7, is called the denominator. The **long division symbol**, $\overline{)}$, is used when computing a division problem.

$21 \div 7$ is written as $7\overline{)21}$

Zero as a Dividend

Zero divided by a number equals zero. For example, $0 \div 5 = 0$. The fact that zero divided by a number equals zero can be shown by multiplication. The expression $0 \div 5 = ?$ means $? \times 5 = 0$. Since 0×5 does equal 0, it is true that $0 \div 5 = 0$.

Zero as a Divisor

Dividing by zero is impossible. Students sometimes confuse division of a number by zero with division of zero by a number. It can be shown by multiplication that a number divided by zero is impossible; it is undefined. The expression $5 \div 0 = ?$ means that $? \times 0 = 5$. Since there is no real number that can be multiplied by 0 to equal 5, the division, $5 \div 0$, is not possible.

In the case of $0 \div 0 = ?$, there is not a unique solution, but there are infinite solutions. The expression $0 \div 0 = ?$ means $? \times 0 = 0$. Since any number times 0 equals 0, the division $0 \div 0$ has no unique solution and is also not possible.

Procedure for Dividing Whole Numbers

Write the numbers of the division problem with the divisor outside the left side of the long division symbol and the dividend within the symbol. In any division problem, the answer multiplied by the divisor plus the remainder equals the dividend.

EXAMPLE

Divide. 4505 ÷ 6

Estimate the answer. Round 4505 to 4500.

4500 ÷ 6. The answer will be between 700 and 800.

Compute the answer.

Write the problem with the divisor outside and at the left of the long division symbol and the dividend within the symbol.

The divisor, 6, is not contained in 4, the number of thousands. The 6 will divide the 45, which is the number of hundreds. Write the 7 in the answer above the hundreds place. Multiply 7 × 6 = 42. Subtract 42 hundreds from 45 hundreds. Write the 3 hundreds remainder in the hundreds column, and bring down the 0 tens from the dividend.

```
   7 5 0  R 5 Ans
6)4 5 0 5
  4 2
    3 0
    3 0
      5
      0
      5
```

Divide 30 tens by 6. Write the 5 in the answer above the tens place. Subtract 30 tens from 30 tens. Bring down the 5, from the dividend, in the units column.

Divide 5 by 6. Since 6 is not contained in 5, write 0 in the answer above the units place. Subtract 0 from the 5. The remainder is 5.

The answer is 750 R 5.

```
  7 5 0      4 5 0 0
×     6    +       5
4 5 0 0      4 5 0 5 Ck
```

Check the answer to the estimate.

750 R 5 is between 700 and 800.

Check by multiplying the answer by the divisor and adding the remainder.

Selecting Trial Quotients

In solving long division problems, often the trial quotient selected is either too large or too small. When this occurs, another trial quotient must be selected.

EXAMPLE

Divide 68,973 by 76.

Estimate the answer. Round 76 to 80 and 68,973 to 70,000.

70,000 ÷ 80 = 7000 ÷ 8. The answer is approximately 900.

Compute the answer.

Write the divisor and dividend in the proper positions.

The divisor 76 is not contained in 6 or 68.

Divide 689 hundreds by 76. The partial quotient is estimated as 8.

Multiply: 8 × 76 = 608

Subtract: 689 − 608 = 81

The remainder 81 is greater than the divisor 76.

The partial quotient is too small and must be increased to 9.

```
      8
7 6)6 8 9 7 3
    6 0 8
      8 1
```

INCORRECT: *Trial quotient must be increased to 9.*

NOTE: *The remainder 81 is greater than the divisor 76.*

The problem is now correctly solved.

Divide: 689 ÷ 76

Write 9 in the partial quotient.

Multiply: 9 × 76 = 684

Subtract: 689 − 684 = 5

Bring down the 7.

```
     9 0 7  R 41 Ans
7 6)6 8 9 7 3
    6 8 4
      5 7 3
      5 3 2
        4 1
```

Divide: 57 ÷ 76 = 0
Write 0 in the partial quotient.
Bring down the 3.
Divide: 573 ÷ 76
Estimate 8 as the trial divisor.
Multiply: 8 × 76 = 608
Since 608 cannot be subtracted from 573, the trial quotient, 8, is too large and must be decreased to 7.
Multiply: 7 × 76 = 532
Subtract: 573 − 532 = 41
The answer is 907 with a remainder of 41.

Check the answer to the estimate.
907 R 41 is approximately the same as 900.

Check by multiplying the answer by the divisor and adding the remainder.

```
  907
 × 76
 5442
6349
6893 2
```

```
 6893 2
+    41
 6897 3 Ck
```

Maintain proper place value in division. Zeros must be shown in the quotient over their respective digits in the dividend.

EXAMPLE

Divide. 24,315,006 ÷ 4863

```
          5000 R 6 Ans
4863)24,315,006
     24,315
        006
```

Check:
```
  4863
× 5000
24,315,000
```

```
24,315,000
+         6
24,315,006 Ck
```

EXERCISE 1–9 POWERUP

These Power Up exercises review concepts that you studied earlier. Use them to refresh your skills before you attempt this exercise set.

Estimate the products in problems 1 through 4.

1. 68 × 7
2. 142 × 8
3. 814 × 35
4. 21,726 × 434

Multiply and check. Compare your answers with your estimates in problems 1 through 4.

5. 68 × 7
6. 142 × 8
7. 814 × 35
8. 21,726 × 434

ESTIMATING QUOTIENTS

Estimate each of the following quotients.

9. 3)261
10. 9)405
11. 6)408
12. 9)1962
13. 8)20,376
14. 4)26,356
15. 7)479,997
16. 2)3811
17. 5)53,043
18. 8)98,951

DIVIDING WHOLE NUMBERS

Divide and check. In problems 19 through 28 compare your answers with your estimates in problems 9 through 18.

19. $3\overline{)261}$
20. $9\overline{)405}$
21. $6\overline{)408}$
22. $9\overline{)1962}$
23. $8\overline{)20{,}376}$
24. $4\overline{)26{,}356}$
25. 479,997 ÷ 7
26. 3811 ÷ 2
27. 53,043 ÷ 5
28. $\frac{98{,}951}{8}$
29. $\frac{413{,}807}{3}$
30. $\frac{700{,}514}{9}$
31. $27\overline{)486}$
32. $43\overline{)559}$
33. $32\overline{)7712}$
34. $46\overline{)9522}$
35. 36,650 ÷ 68
36. 95,631 ÷ 122
37. 30,007 ÷ 604
38. $323\overline{)69{,}768}$
39. $618\overline{)78{,}486}$
40. 461,079 ÷ 924
41. 65,000 ÷ 800
42. $\frac{799{,}981}{542}$
43. $\frac{194{,}072}{2624}$
44. $\frac{461{,}312}{2176}$
45. $\frac{7{,}808{,}510}{3776}$
46. $\frac{6{,}700{,}405}{4062}$

1–10 MULTIPLYING AND DIVIDING WHOLE NUMBERS IN PRACTICAL APPLICATIONS

EXAMPLE

The total cost of fixtures and luminaries for an office lighting installation is found by an electrician. The following fixtures and luminaries are specified: 12 LED fixtures at $18 each, 22 semidirect CFL luminaries at $37 each, and 33 direct CFL luminaries at $28 each. Find the total cost.

Determine the procedure.

Multiply the required number of each luminary or fixture by the cost of each. The total cost is the sum of the products.

Estimate the answer.

Total cost = (10 × $20) + (20 × $40) + (30 × $30)

Total cost = $200 + $800 + $900 = $1900

Compute the answer.

Total cost = (12 × $18) + (22 × $37) + (33 × $28)

Total cost = $216 + $814 + $924 = $1954 ANS

Check the answer to the estimate.

$1954 is approximately the same as $1900.

EXERCISE 1–10

POWERUP

These Power Up exercises review concepts that you studied earlier. Use them to refresh your skills before you attempt this exercise set.

Estimate the product or quotient in problems 1 through 4.

1. 157 × 28
2. 762 × 64
3. $7\overline{)408}$
4. $6\overline{)14562}$

Divide and check problems 5 and 6. Compare your answers to the estimates in problems 3 and 4.

5. $7\overline{)408}$
6. $6\overline{)14562}$

WHOLE NUMBER APPLICATIONS

7. An offset press feeds at the rate of 2050 impressions per hour. How many impressions can a press operator print in 14 hours?
8. A chef estimates that an average of 150 pounds of ground beef are prepared daily. How many pounds of ground beef should be ordered for a 4-week supply? The restaurant is closed only on Mondays.
9. A welder fabricates 22 steel water tanks for a price of $20,570. Find the cost of each tank.
10. A tractor-trailer operator totals diesel fuel bills for 185 gallons of fuel used in a week. The truck travels 1665 miles during the week. How many miles per gallon does the truck average?
11. Two sets of holes are drilled by a machinist in a piece of aluminum flat stock, as shown in Figure 1–7. All dimensions are in millimeters.
    a. Find, in millimeters, dimension A.
    b. Find, in millimeters, dimension B.

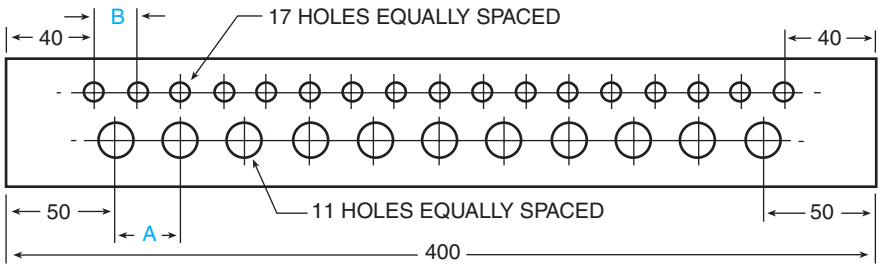


FIGURE 1–7

NOTE: *Whenever holes are arranged in a straight line, the number of spaces is one less than the number of holes.*

12. In a commercial bakery, roll dividing machines produce 16,000 dozen rolls in 8 hours. Determine the number of single rolls produced per minute.
13. An architectural engineering assistant determines the total weight of I beams required for a proposed building. Figure 1–8 lists the data used in finding the weight. Find the total weight of all I beams for the building.

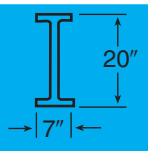
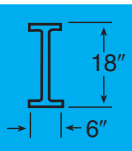
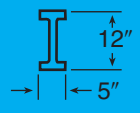
	 20″ 7″ **20″ × 7″ I Beams Weight: 80 lb/ft**	 18″ 6″ **18″ × 6″ I Beams Weight: 55 lb/ft**	 12″ 5″ **12″ × 5″ I Beams Weight: 32 lb/ft**
Number of 10-foot lengths	15	0	24
Number of 16-foot lengths	12	18	7
Number of 20-foot lengths	8	32	25
Number of 24-foot lengths	17	8	0

FIGURE 1–8

NOTE: *The table shows the cross-section dimensions of each type of I beam. The weights given are for 1 foot of length for each type of I beam.*

14. An apartment complex is being built; it will have 318 apartments. Each workday heating and air-conditioning systems can be installed in 6 apartments. How many workdays are required to complete installations for the complete complex?
15. A gasoline dealer estimated that during the month of July (25 business days), an average of 6500 gallons of gasoline would be sold each day. During July, a total of 175,700 gallons are actually sold. How many more gallons are sold than were estimated for the month?
16. A cosmetologist determines that an average of 3 ounces of liquid shampoo are required for each shampooing application. The beauty salon has 9 quarts of shampoo in stock. How many shampooing applications are made with the shampoo in stock?
    NOTE: *One quart contains 32 ounces.*
17. A very small electromagnet is wound with 84 layers. Each layer requires 237 turns.
    a. Round each number to the nearest ten and approximate the total number of turns on the magnet.
    b. What is the actual number of turns on the magnet?
18. A mechanic is paid $17 an hour. How much is earned in a 37-hour week?
19. An ornamental iron fabricator finds the material requirements for the railing shown in Figure 1–9. How many vertical pieces of 1-inch square wrought iron are needed for this job?

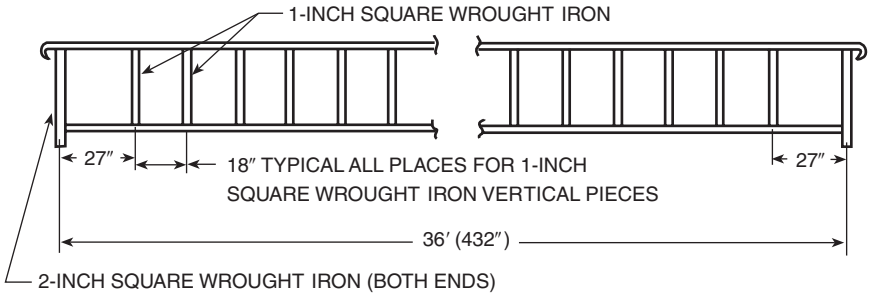


FIGURE 1–9

20. In estimating the time required to complete a proposed job, an electrical contractor determines that a total of 735 hours are needed. Three electricians each work 5 days per week for 7 hours per day. How many weeks are required to complete the job?
21. The size of air-conditioning equipment needed in a building depends on the number of windows and the location of the windows. Figure 1–10 lists the number and the amount of square feet of four different sizes of windows. The heat gain through glass in Btu/h for each square foot of glass area is shown on the table. A btu (British thermal unit) is a unit of heat. Find the total heat gain (btu/h) for the building.

	NUMBER OF WINDOWS AT EACH SIDE OF BUILDING			
Window Size (Number of square feet)	North Side 25 Btu/h/sq ft	South Side 76 Btu/h/sq ft	East Side 90 Btu/h/sq ft	West Side 99 Btu/h/sq ft
15 sq ft	8	10	4	6
24 sq ft	9	6	2	7
32 sq ft	0	4	0	3
36 sq ft	2	2	1	1

FIGURE 1–10

22. An excavating contractor finds that a piece of land must be drained of water before work on a job can begin. Two pumps are used to drain the water. One pump operates at the rate of 70 liters per minute for 30 minutes. The second pump operates at a rate of 90 liters per minute for 45 minutes. How many liters of water are pumped by both pumps?

23. A chef plans the menu for a particular reception for 161 guests. The appetizer is a 6-ounce serving of tomato juice for each guest. How many 46-ounce cans of tomato juice are ordered for this reception?
24. A bookcase shown in Figure 1–11 is produced in quantities of 1500 by a furniture manufacturer. All pieces, except the top and back, are made from 12-inch-wide lumber. One foot of stock is allowed for cutting and waste for each bookcase. Find the total number of feet of 12-inch stock needed to manufacture the 1500 units.

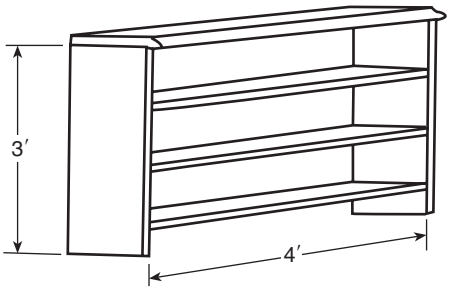


FIGURE 1–11

25. A 192-foot length of Romex cable needs to be stapled. The staples are evenly spaced with a staple at the beginning and another at the end of the cable. If 49 staples are used, how far apart should the staples be placed?
26. A certain wiring job requires 17,842 feet of Romex cable.
    a. Round this amount to the nearest thousand feet.
    b. Romex cable is packaged in 250-foot rolls. How many rolls should be ordered for this job?

1–11 COMBINED OPERATIONS OF WHOLE NUMBERS

Many occupations require the use of combined operations in solving arithmetic expressions. The arithmetic expressions are often given as formulas in occupational textbooks, manuals, and other related occupational reference materials. A **formula** uses symbols to show the relationship between quantities. The formula used in the electrical industry to find the number of kilowatts (kW) of power (P) in terms of voltage (E) and current (I) is

$$P = \frac{E \times I}{1000}$$

where voltage is expressed in volts, and current is expressed in amperes.

Order of Operations

Following the proper order of operations is a basic requirement in solving problems involving the use of formulas. A given arithmetic expression must have a unique solution. The expression $3 + 5 \times 4$ must have only one answer. The correct answer, 23, is found by using the following order of operations rules.

Order of Operations

- First, do all operations within grouping symbols. Grouping symbols are parentheses ( ), brackets [ ], and braces { }. The fraction bar is also a symbol used as a grouping symbol. Think of the numerator and denominator as if each is enclosed in parentheses. If parentheses are enclosed in other parentheses, work from the inside out.
- Raise to a power. This is sometimes called exponentiation and includes finding roots. It will be discussed later.
- Next, do multiplication and division operations in order from left to right.
- Last, do addition and subtraction operations in order from left to right.

Some people use the memory aid "**P**lease **E**xcuse **M**y **D**ear **A**unt **S**ally" to help them remember the order of operations. The **P** in "Please" stands for parentheses, the **E** for exponents or raising to a power, **M** and **D** for multiplication and division, and the **A** and **S** for addition and subtraction.

EXAMPLES

1. Find the value of $(15 + 6) \times 3 - 28 \div 7$.

   Do the work in parentheses.
   Multiply and divide.
   Subtract.

$$\begin{aligned}(15 + 6) \times 3 - 28 \div 7 \\ 21 \times 3 - 28 \div 7 \\ 63 - 4 \\ 59 \text{ ANS}\end{aligned}$$

2. Evaluate $(27 + 9) \times (12 - 7)$.

   Do the work in parentheses.
   Multiply.

$$\begin{aligned}(27 + 9) \times (12 - 7) &= 36 \times (12 - 7) \\ &= 36 \times 5 \\ &= 180 \text{ ANS}\end{aligned}$$

3. Determine the value of $36 - (29 - (42 - (8 + 16)))$.

   Do the work in the innermost parentheses.
   Now work in the innermost of the remaining parentheses.
   Do the work in the final parentheses.
   Subtract.

$$\begin{aligned}36 - (29 - (42 - (8 + 16))) &= 36 - (29 - (42 - 24)) \\ &= 36 - (29 - 18) \\ &= 36 - 11 \\ &= 25 \text{ ANS}\end{aligned}$$

4. Find the value of $\dfrac{120 - 25 \times 3}{12 + 24 \div 8} + 10$.

   The fraction bar is the grouping symbol.
   Do all work above and below the bar first.
   Divide.
   Add.

$$\begin{aligned}&\frac{120 - 25 \times 3}{12 + 24 \div 8} + 10 \\ &\frac{120 - 75}{12 + 3} + 10 \\ &\frac{45}{15} + 10 \\ &3 + 10 \\ &13 \text{ ANS}\end{aligned}$$

EXERCISE 1-11 POWERUP

These Power Up exercises review concepts that you studied earlier. Use them to refresh your skills before you attempt this exercise set.

Estimate the answer in problems 1 through 4.

1. $487 + 972$
2. $1462 - 973$
3. 621×37
4. $9\overline{)2436}$

In problems 5 and 6, perform the indicated operation and check. Compare your answers to the estimates in problems 2 and 4, respectively.

5. $1462 - 973$
6. $9\overline{)2436}$

COMBINED OPERATIONS WITH WHOLE NUMBERS

Perform the indicated operations.

7. $7 + 8 - 6$
8. $26 - 9 + 3$
9. $57 + 18 - 14$
10. $94 - 87 + 32 - 27$
11. $26 + 16 \div 4$
12. $(28 + 16) \div 4$
13. $\frac{72}{8} + 40$
14. $\frac{72 + 40}{8}$
15. $(85 + 51) \div 4$
16. $\frac{25 - 13 + 4}{2}$
17. $25 - 13 + \frac{4}{2}$
18. $11 \times (8 - 5) + 9 \times (2 + 7)$
19. $11 \times 8 - 5 + 9 \times 2 + 7$
20. $\frac{3 \times (29 - 6)}{23}$
21. $\frac{324}{9} + \frac{288}{48}$
22. $\frac{253 - 17 \times 3}{85 + 52 - 36}$
23. $8 \times 12 + 60 \div (9 + 3)$
24. $8 \times (12 + 60) \div (9 + 3)$
25. $(8 \times 12 + 60) \div (9 + 3)$
26. $\left(\frac{81}{9} + 14\right) \times 5$
27. $\frac{81}{9} + (14 \times 5)$
28. $41 + 3 \times 7 - 6$
29. $41 + 3 \times (7 - 6)$
30. $(15 \times 6) \div (3 \times 5)$
31. $(142 - 37) \div (7 \times 5)$
32. $\frac{14 + 10 \times 7}{4 + 2}$
33. $(276 - 84) \times 8 \div 12$
34. $30 \times (10 \times 4 - 40) \div (18 - 7)$
35. $\frac{157 - 21 \times 3}{5 - 18 \div 6} + 17$
36. $86 + \frac{27 + 8 - 5}{6} - 31$
37. $(8 \times 6 - 20) \div (7 + 21)$
38. $(8 \times 6 - 20) \div 7 + 21$
39. $\frac{576 - 16 \times 10 \times 3}{44 - 18 \times 2} - (12 - 9)$
40. $\frac{16 + 6 \times 21}{157 - 12 \times 13} - \frac{10 + 3 - 7}{46 - 4 \times 10}$

1–12 COMBINED OPERATIONS OF WHOLE NUMBERS IN PRACTICAL APPLICATIONS

EXAMPLE

An engineering technician is required to determine the size circle (diameter) needed to make the part shown in Figure 1–12. The part (a segment) must be contained within a circle. The length, dimension *c*, must be 20 inches and the height, dimension *h*, must be 5 inches. The technician looks up the formula in a handbook.

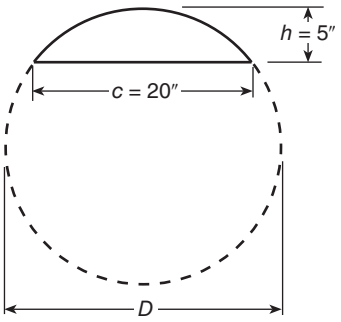


FIGURE 1–12

$$D = \frac{c \times c + 4 \times h \times h}{4 \times h}$$

where D = diameter
c = length of chord
h = height of segment

Substitute the numerical values for the variables.

$$\frac{20 \times 20 + 4 \times 5 \times 5}{4 \times 5}$$

The fraction bar is the grouping symbol. Do the work above and below the bar.

$$\frac{400 + 100}{20}$$

Divide.

$$\frac{500}{20}$$

The diameter of the circle should be 25 inches.

25″ ANS

EXERCISE 1–12

POWERUP

These Power Up exercises review concepts that you studied earlier. Use them to refresh your skills before you attempt this exercise set.

Estimate the answer in problems 1 through 4.

1. 2691 + 4368 + 563
2. 21,496 − 2749
3. 435 × 127
4. $3\overline{)25415}$

In problems 5 and 6, perform the indicated operation and check. Compare your answers to the estimates in problems 1 and 3, respectively.

5. 2691 + 4368 + 563
6. 435 × 127

PRACTICAL APPLICATIONS

7. Electrical power (P) in kilowatts equals voltage (E) in volts times current (I) in amperes divided by 1000.

$$P = \frac{E \times I}{1000}$$

Find the number of kilowatts of power using the values given in the table in Figure 1–13.

	Voltage (E) (in volts)	Current (I) (in amperes)	Power (P) (in kilowatts)
a.	110	100	
b.	115	200	
c.	220	150	
d.	230	100	
e.	220	50	

FIGURE 1–13

8. A retailer borrows $4700 from a bank for 30 months. Using an installment loan table, the monthly payment on $4000 is $158. The monthly payment on $700 is $27.65. How much total interest must the retailer pay the bank?

Total interest = (monthly payment on $4000 + monthly payment on $700) × 30 − amount borrowed

9. An electrical circuit in which three cells are connected in series is shown in Figure 1–14.

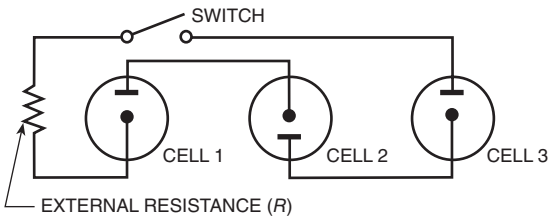


FIGURE 1–14

Compute the number of amperes of current in circuits a, b, and c using the values given in the table in Figure 1–15.

$$I = \frac{E \times ns}{r \times ns + R}$$

where E = voltage of one cell in volts
ns = number of cells in circuit
r = internal resistance of one cell in ohms
R = external resistance of circuit in ohms
I = current in amperes

	E	ns	r	R	I
a.	2 volts	3 cells	1 ohm	3 ohms	
b.	5 volts	3 cells	1 ohm	2 ohms	
c.	6 volts	3 cells	1 ohm	3 ohms	

FIGURE 1–15

10. Carpenters find amounts of lumber needed in board feet (bd ft). A board foot is the equivalent of a piece of lumber 1 foot wide, 1 foot long, and 1 inch thick.

$$\text{bd ft} = \frac{T \times W \times L}{12}$$

where T = thickness in inches
W = width in inches
L = length in feet

Find the number of board feet in each piece of lumber shown in Figure 1–16.

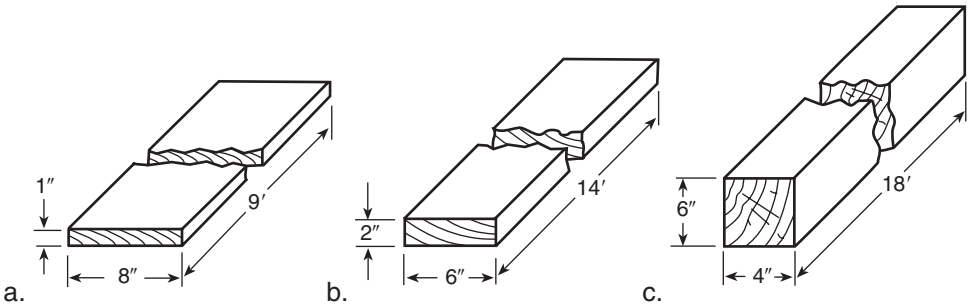


FIGURE 1–16

11. A comparison between Fahrenheit and Celsius scales is shown in Figure 1–17. Express the temperatures given as equivalent degrees Fahrenheit or degrees Celsius readings.

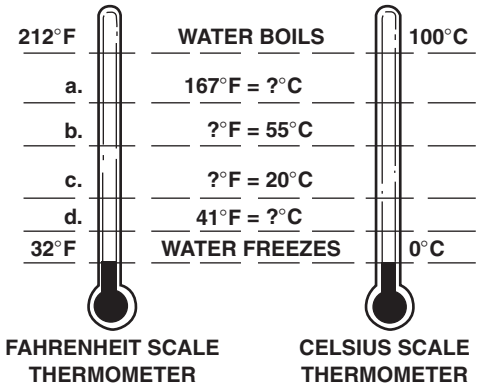


FIGURE 1–17

To express degrees Fahrenheit in degrees Celsius, use

$$°C = \frac{5 \times (°F - 32)}{9}$$

To express degrees Celsius in degrees Fahrenheit, use

$$°F = \frac{9 \times °C}{5} + 32$$

12. An electronics technician finds the total resistance (R_T) in ohms for the circuit shown in Figure 1–18.

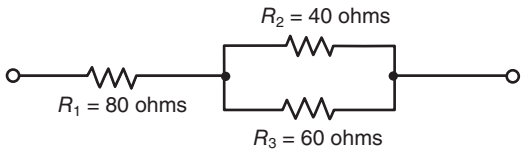


FIGURE 1–18

The individual resistances are represented by the symbols R_1, R_2, and R_3. Find the total resistance of the circuit.

$$R_T = R_1 + \frac{R_2 \times R_3}{R_2 + R_3}$$

UNIT EXERCISE AND PROBLEM REVIEW

PLACE VALUE

Write the place value for the specified digit of each number given in the table.

	Digit	Number	Place Value
1.	3	6938	
2.	5	519	
3.	7	27,043	
4.	8	5,810,612	
5.	0	60,443	
6.	2	2706	

EXPANDING WHOLE NUMBERS

Write each whole number in expanded form.

7. 48
8. 319
9. 13,692
10. 863
11. 5103
12. 6,600,000

ROUNDING WHOLE NUMBERS

Round each number as indicated.

13. 9247 (nearest hundred)
14. 25,371 (nearest thousand)
15. 75,099 (nearest thousand)
16. 152,257 (nearest thousand)
17. 152,257 (nearest hundred)
18. 24,499 (nearest thousand)

ADDITION OF WHOLE NUMBERS

Estimate the sum, then add and check.

19. $\begin{array}{r} 43 \\ +54 \\ \hline \end{array}$

20. $\begin{array}{r} 67 \\ +84 \\ \hline \end{array}$

21. $\begin{array}{r} 123 \\ +\ 96 \\ \hline \end{array}$

22. $\begin{array}{r} 586 \\ +787 \\ \hline \end{array}$

23. $\begin{array}{r} 8463 \\ +\ 388 \\ \hline \end{array}$

24. $\begin{array}{r} 30{,}736 \\ +\ 9405 \\ \hline \end{array}$

25. $\begin{array}{r} 87{,}495 \\ +96{,}986 \\ \hline \end{array}$

26. $\begin{array}{r} 186{,}693 \\ +557{,}935 \\ \hline \end{array}$

27. $707 + 932 + 13$

28. $6057 + 443 + 697$

29. $152{,}077 + 2073 + 16{,}478$

30. $84 + 30{,}309 + 129{,}427$

SUBTRACTION OF WHOLE NUMBERS

Estimate the difference, then subtract and check.

31. $\begin{array}{r} 47 \\ -14 \\ \hline \end{array}$

32. $\begin{array}{r} 84 \\ -31 \\ \hline \end{array}$

33. $\begin{array}{r} 90 \\ -37 \\ \hline \end{array}$

34. $\begin{array}{r} 86 \\ -49 \\ \hline \end{array}$

35. $\begin{array}{r} 787 \\ -612 \\ \hline \end{array}$

36. $\begin{array}{r} 212 \\ -109 \\ \hline \end{array}$

37. $\begin{array}{r} 700 \\ -387 \\ \hline \end{array}$

38. $\begin{array}{r} 1707 \\ -\ 983 \\ \hline \end{array}$

39. $1955 - 1947$

40. $4304 - 3770$

41. $12{,}621 - 9097$

42. $47{,}435 - 8707$

43. $874{,}906 - 51{,}109$

44. $885{,}172 - 79{,}453$

MULTIPLICATION OF WHOLE NUMBERS

Estimate the product, then multiply and check.

45. $\begin{array}{r} 412 \\ \times\ \ 9 \\ \hline \end{array}$

46. $\begin{array}{r} 56 \\ \times 19 \\ \hline \end{array}$

47. $\begin{array}{r} 8055 \\ \times\ 903 \\ \hline \end{array}$

48. $\begin{array}{r} 14{,}932 \\ \times\ 8206 \\ \hline \end{array}$

49. 7778×9380

50. 3305×5617

51. $70{,}000 \times 80{,}000$

52. $7 \times 10 \times 5 \times 2$

53. $3 \times 22 \times 20$

54. $8 \times 19 \times 78$

55. $55 \times 66 \times 77$

56. $8 \times 913 \times 72$

57. $61 \times 200 \times 816$

DIVISION OF WHOLE NUMBERS

Estimate the quotient, then divide and check.

58. $8\overline{)624}$

59. $6\overline{)6012}$

60. $67{,}393 \div 9$

61. $\dfrac{470{,}362}{9}$

62. $52\overline{)832}$

63. $16\overline{)4848}$

64. $89\overline{)356{,}712}$

65. $814\overline{)13{,}838}$

66. $38{,}141 \div 177$

67. $59{,}492 \div 111$

68. $\dfrac{371{,}844}{2817}$

69. $\dfrac{312{,}906}{3981}$

COMBINED OPERATIONS OF WHOLE NUMBERS

Estimate the answer and then perform the indicated operations.

70. $9 + 15 - 14$

71. $30 + 21 \div 3$

72. $(46 + 26) \div 12$

73. $\dfrac{104 + 32}{8}$

74. $67 - 42 + \frac{15}{3}$

75. $31 + 7 \times (14 - 3)$

76. $31 + 7 \times 14 - 3$

77. $\frac{46 + 18 \times 5}{19 - 11}$

78. $(273 - 194) \times 16 \div 4$

79. $12 \times (10 - 3) + 7 \times (3 + 6)$

80. $\frac{6 \times (21 - 7)}{21}$

81. $\frac{140 - 21 \times 5}{122 - 119 + 4}$

82. $(9 \times 8 + 34) \div (42 + 11)$

83. $\frac{125}{5} + 12 \times 7$

84. $\frac{128 - 16 \times 2}{9 - 21 \div 3}$

85. $47 - \frac{83 + 16 - 51}{8} + 13$

86. $(19 \times 5 - 20) \div 5 - 3$

87. $40 \times (15 \times 4 - 42) \div 90$

88. $\frac{282 - 14 \times 3 \times 6}{6} - (21 - 16)$

89. $\frac{36 + 7 \times 21}{61} + \frac{34 - 18 - 6}{31 \times 8 - 243}$

WHOLE NUMBER PRACTICAL APPLICATION PROBLEMS

Solve the following problems.

90. During the first week of April, a print shop used the following paper stock: 5570 sheets on Monday, 7855 sheets on Tuesday, 7236 sheets on Wednesday, 6867 sheets on Thursday, and 6643 sheets on Friday. During the following week, 4050 more sheets are used than during the first week. Find the total sheets used during the first 2 weeks of April.

91. A five-floor apartment building has eight electrical circuits per apartment. There are six apartments per floor. How many electrical circuits are there in the building?

92. The invoice shown in Figure 1–19 is mailed to the Center Sports Shop by a billing clerk of the m & N Sports Equipment manufacturing Company. (An invoice is a bill sent to a retailer by a manufacturer or wholesaler for merchandise purchased by the retailer.) The extension shown in the last column of the invoice is the product of the number (quantity) of units multiplied by the price of one unit. Find the extension amount for each item on the invoice and add the extensions to determine total cost.

	Quantity	Unit	Unit Price	Description	Extension
a.	15	dozen	$ 2	Floats	$30
b.	24	each	$21	Fishing rods	
c.	1	box	$18	Spools of line	
d.	18	each	$ 9	Reels	
e.	36	each	$ 7	Baseball bats	
f.	5	box	$36	Baseballs	
g.	24	package	$ 8	Golf balls	
h.	15	each	$17	Putters	
i.				Total Cost _____	

FIGURE 1–19

93. The drill jig shown in Figure 1–20 is laid out by a machine drafter. All dimensions are in millimeters.
    a. Find, in millimeters, dimension A.
    b. Find, in millimeters, dimension B.
    c. Find, in millimeters, dimension C.

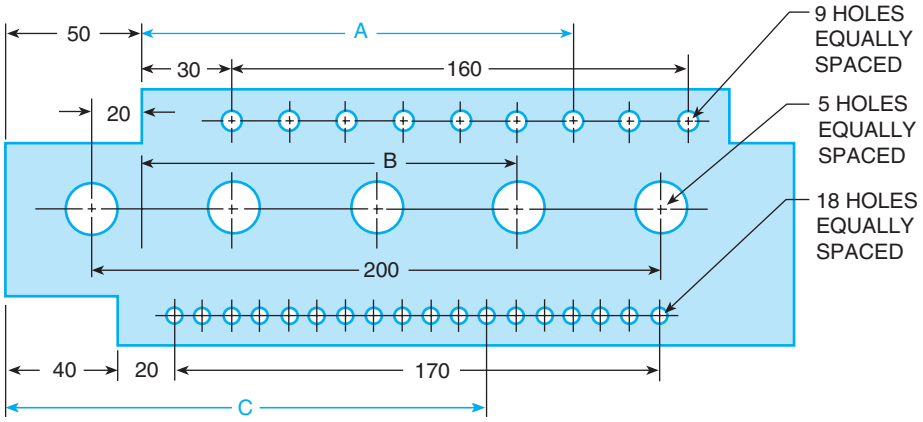


FIGURE 1–20

94. Figure 1–21 shows the front view of a wooden counter that is to be built for a clothing store. All pieces of the counter except the top and back are to be made of the same thickness and width of lumber. How many total feet (1 foot = 12 inches) of lumber should be ordered for this job? Do not include the top or back. Allow 6 feet for waste.

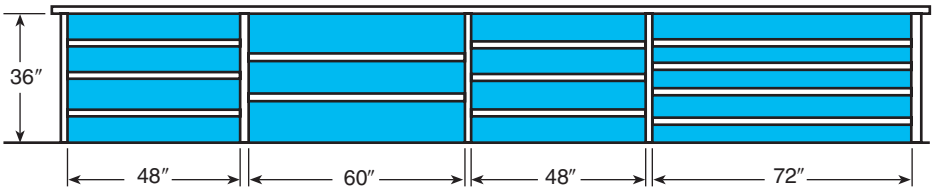


FIGURE 1–21

95. An 8-pound cut of roast beef is to be medium roasted at 350°F. Total roasting time is determined by allowing 15 minutes roasting time for each pound of beef. If the roast is placed in a preheated oven at 2:00 P.M., at what time should it be removed?

96. The accountant for a small manufacturing firm computes the annual depreciation of each piece of tooling, equipment, and machinery in the company. From a detailed itemized list, the accountant groups all items together that have the same life expectancy (number of years of usefulness) as shown in Figure 1–22. Find the annual depreciation for each group and the total annual depreciation of all tooling, equipment, and machinery, using the straight-line formula.

Annual depreciation = (Cost − Final value) ÷ Number of years of usefulness

	Group	Cost	Final Value	Number of Years of Usefulness	Annual Depreciation
a.	Tooling	$14,500	$1200	5 years	
b.	Equipment	$28,350	$3750	6 years	
c.	Equipment	$17,900	$2040	10 years	
d.	Machinery	$67,700	$7940	8 years	
e.	Machinery	$80,300	$10,600	10 years	
f.	Total Annual Depreciation				

FIGURE 1–22

97. A landscaper contracts to provide topsoil and to seed and lime the parcel of land shown in Figure 1–23. In order to determine labor and material costs, the landscaper must first know the total area of the land. Find the total area in square feet.

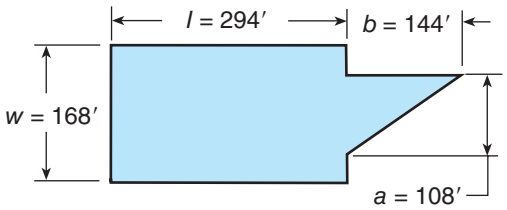


FIGURE 1–23

Total area (square feet) $= l \times w + (a \times b) \div 2$

98. The formula called Young's Rule is used in the health field to determine a child's dose of medicine.

Child's dose = (Age of child) ÷ (Age of child + 12) × Average adult dose

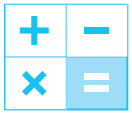
What dose (number of milligrams) of morphine sulfate should be given to a 3-year-old child if the adult dose is 10 milligrams?

99. During one week period, a mechanic works 37 hours and has a gross pay of $592. You need to determine the mechanic's hourly pay.
   a. What is the divisor?
   b. What is the dividend?
   c. What was the mechanic's actual hourly pay?

100. An contractor employs 23 people. Six of them earn $14 per hour, 12 people earn $15 per hour, and the rest earn $18 per hour.
   a. What is the total hourly wage for all 23 people?
   b. If each employee works 38 hours a week, what are the total wages in one week?
   c. The contractor must pay an additional $1029 to the federal government to cover Social Security and Medicare for these employees. How much did the employer have to pay this week to the employees and government?

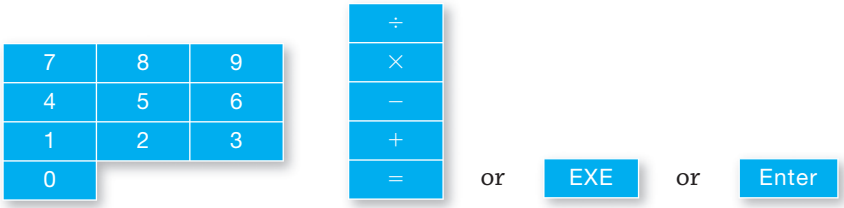
1–13 COMPUTING WITH A CALCULATOR: WHOLE NUMBERS

Basic Arithmetic Functions



The digit keys are used to enter any number into the display in a left-to-right order.

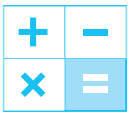
The operations of addition, subtraction, multiplication, and division are performed with the four arithmetic keys and the equals key. The equals key completes all operations entered and readies the calculator for additional calculations. Certain makes and models of calculators have the execute key EXE or the enter key ENTER instead of the equals key =. If your calculator has the execute key, substitute EXE for = in the examples that follow. If your calculator has the enter key, substitute ENTER for =.



Examples of each of the four arithmetic operations of addition, subtraction, multiplication, and division are presented. Following the individual operation problems, combined operations expressions are given with calculator solutions. Make it a practice to estimate answers before doing calculator computations. Compare the estimate to the

calculator answer. Also, check the answer to a problem by doing the problem a second time to ensure that improper data was not entered. Remember to clear or erase previously recorded data and calculations before doing a problem. Depending on the make and model of the calculator, press [AC] or [CLEAR] *once* or [ON/C], *twice*.

Individual Arithmetic Operations

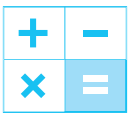


NOTE: *Because each of the following examples is of a single type of arithmetic operation, combined operations are not involved. Therefore, it is not required that a calculator with algebraic logic be used to solve this set of problems.*

EXAMPLES

1. Add. 37 + 85
   Solution. 37 [+] 85 [=] 122 ANS
2. Add. 95 + 17 + 102 + 44
   Solution. 95 [+] 17 [+] 102 [+] 44 [=] 258 ANS
   Some calculators have both a [−] and a [(−)] key. The [−] is used for subtraction. We will see later how to use the [(−)] key.
3. Subtract. 95 − 37
   Solution. 95 [−] 37 [=] 58 ANS
4. Subtract. 126 − 84 − 15
   Solution. 126 [−] 84 [−] 15 [=] 27 ANS
5. Multiply. 216 × 13
   Solution. 216 [×] 13 [=] 2808 ANS
6. Multiply. 49 × 7 × 84 × 12
   Solution. 49 [×] 7 [×] 84 [×] 12 [=] 345,744 ANS
7. Divide. 378 ÷ 27
   Solution. 378 [÷] 27 [=] 14 ANS

Combined Arithmetic Operations



NOTE: *Because the following problems are combined operations expressions, your calculator must have algebraic logic to solve the problems as shown. The expressions are solved by entering numbers and operations into the calculator in the same order as the expressions are written.*

EXAMPLES

1. Evaluate. 28 + 16 ÷ 4
   Solution. 28 [+] 16 [÷] 4 [=] 32 ANS
   Because the calculator has algebraic logic, the division operation (16 ÷ 4) was performed before the addition operation (adding 28) was performed.
   NOTE: *If the calculator does not have algebraic logic, the answer to the expression if solved in the order as shown is incorrect:* 28 [+] 16 [÷] 4 [=] 11 *INCORRECT ANSWER. The calculator merely performed the operations in the order entered, without assigning priorities to various operations, and gave an incorrect answer. If your calculator does not have algebraic logic, then you will have to remember to put in the parentheses.*
2. Evaluate. 11 × 8 − 5 + 9 × 2 + 7
   Solution. 11 [×] 8 [−] 5 [+] 9 [×] 2 [+] 7 [=] 108 ANS
3. Evaluate. $35 - \frac{21}{3} + 18 \times 12$
   Solution. 35 [−] 21 [÷] 3 [+] 18 [×] 12 [=] 244 ANS

4. Evaluate. $8 \times (20 - 7) - 6$

As previously discussed in the section on order of operations, operations enclosed within parentheses are done first. A calculator with algebraic logic performs the operations within parentheses before performing other operations in a combined operations expression. If an expression contains parentheses, enter the expression in the calculator in the order in which it is written. The parentheses keys must be used.

Solution. 8 × (20 − 7) − 6 = 98 ANS

Parentheses keys

5. Evaluate. $46 + (5 + 7) \times (57 - 38)$

Solution. 46 + (5 + 7) × (57 − 38) = 274 ANS

6. Evaluate. $\dfrac{14 + 10 \times 7}{4 + 2}$

Recall that for a problem expressed in fractional form, the fraction bar is also used as a grouping symbol. The numerator and denominator are each considered as being enclosed in parentheses.

$$\frac{14 + 10 \times 7}{4 + 2} = (14 + 10 \times 7) \div (4 + 2)$$

Solution. (14 + 10 × 7) ÷ (4 + 2) = 14 ANS

The expression may also be evaluated by using the = key to simplify the numerator without having to enclose the entire numerator in parentheses. However, parentheses must be used to enclose the denominator.

Solution. 14 + 10 × 7 = ÷ (4 + 2) = 14 ANS

7. Evaluate. $\dfrac{157 - 21 \times 3}{5 - 18 \div 6} + 17$

$$\frac{157 - 21 \times 3}{5 - 18 \div 6} + 17 = (157 - 21 \times 3) \div (5 - 18 \div 6) + 17$$

Solution. (157 − 21 × 3) ÷ (5 − 18 ÷ 6) + 17 = 64 ANS

Using the = key to simplify the numerator:

Solution. 157 − 21 × 3 = ÷ (5 − 18 ÷ 6) + 17 = 64 ANS

8. Evaluate. $\dfrac{100 - (17 + 13)}{112 - 77}$

$$\frac{100 - (17 + 13)}{112 - 77} = (100 - (17 + 13)) \div (112 - 77)$$

Observe these parentheses.

To be sure that the complete numerator is evaluated before dividing by the denominator, the complete numerator must be enclosed within parentheses. This is an example of an expression containing parentheses within parentheses.

Solution. (100 − (17 + 13)) ÷ (112 − 77) = 2 ANS

Using the = key to simplify the numerator:

Solution. 100 − (17 + 13) = ÷ (112 − 77) = 2 ANS

9. Evaluate. $\dfrac{280 \div (32 - 27)}{(47 - 26) \div 3} \times 16$

$$\frac{280 \div (32 - 27)}{(47 - 26) \div 3} \times 16 = (280 \div (32 - 27)) \div ((47 - 26) \div 3) \times 16$$