Elementary Technical Mathematics

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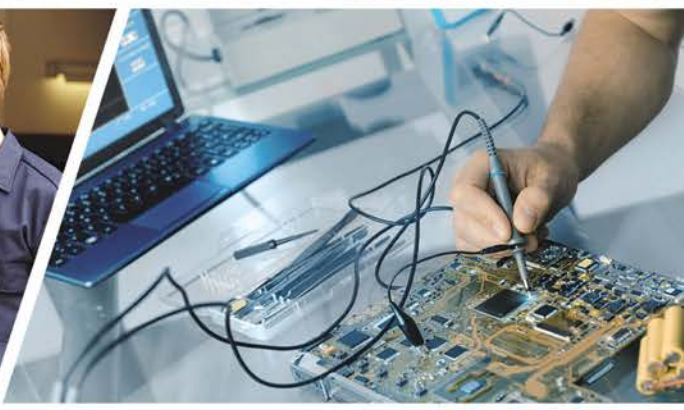

Dale Ewen

Applications Symbols Used in This Text

- Agriculture and Horticulture
- Allied Health
- Auto/Diesel Service
- Aviation
- Business and Personal Finance
- CAD/Drafting
- Culinary Arts
- Electronics
- HVAC
- Industrial and Construction Trades
- Manufacturing
- Natural Resources
- Welding

U.S. Weights and Measures

Length

Standard unit: inch (in. or ″)

12 inches = 1 foot (ft or ′)
3 feet = 1 yard (yd)
5½ yards or 16½ feet = 1 rod (rd)
5280 feet = 1 mile (mi)

Weight

Standard unit: pound (lb)

16 ounces (oz) = 1 pound
2000 pounds = 1 ton

Volume

Liquid

3 teaspoons (tsp) = 1 tablespoon (tbs)
16 tablespoons = 1 cup
2 cups = 1 pint (pt)
16 fluid ounces (fl oz) = 1 pint (pt)
2 pints = 1 quart (qt)
4 quarts = 1 gallon (gal)

Dry

2 pints (pt) = 1 quart (qt)
8 quarts = 1 peck (pk)
4 pecks = 1 bushel (bu)

Metric System Prefixes

Multiple or Submultiple* Decimal Form	Power of 10	Prefix	Prefix Symbol	Pronunciation	Meaning
1,000,000,000,000	10^{12}	tera	T	tĕr′ă	one trillion times
1,000,000,000	10^{9}	giga	G	jĭg′ă	one billion times
1,000,000	10^{6}	mega	M	mĕg′ă	one million times
1,000	10^{3}	kilo**	k	kĭl′ō or kēl′ō	one thousand times
100	10^{2}	hecto	h	hĕk′tō	one hundred times
10	10^{1}	deka	da	dĕk′ă	ten times
0.1	10^{-1}	deci	d	dĕs′ĭ	one tenth of
0.01	10^{-2}	centi**	c	sĕnt′ĭ	one hundredth of
0.001	10^{-3}	milli**	m	mĭl′ĭ	one thousandth of
0.000001	10^{-6}	micro	μ	mī′krō	one millionth of
0.000000001	10^{-9}	nano	n	năn′ō	one billionth of
0.000000000001	10^{-12}	pico	p	pē′kō	one trillionth of

*Factor by which the unit is multiplied.
**Most commonly used prefixes.

As an example, the prefixes are used below with the metric standard unit of length, metre (m).

1 *tera*metre (Tm) = 1,000,000,000,000 m	1 m = 0.000000000001 Tm
1 *giga*metre (Gm) = 1,000,000,000 m	1 m = 0.000000001 Gm
1 *mega*metre (Mm) = 1,000,000 m	1 m = 0.000001 Mm
1 *kilo*metre (km) = 1,000 m	1 m = 0.001 km
1 *hecto*metre (hm) = 100 m	1 m = 0.01 hm
1 *deka*metre (dam) = 10 m	1 m = 0.1 dam
1 *deci*metre (dm) = 0.1 m	1 m = 10 dm
1 *centi*metre (cm) = 0.01 m	1 m = 100 cm
1 *milli*metre (mm) = 0.001 m	1 m = 1,000 mm
1 *micro*metre (μm) = 0.000001 m	1 m = 1,000,000 μm
1 *nano*metre (nm) = 0.000000001 m	1 m = 1,000,000,000 nm
1 *pico*metre (pm) = 0.000000000001 m	1 m = 1,000,000,000,000 pm

12th Edition

Elementary Technical Mathematics

Dale Ewen
Parkland Community College

CENGAGE

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Twelfth Edition
Dale Ewen

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Natural Resources

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PREFACE

Elementary Technical Mathematics, Twelfth Edition, is intended for technical, trade, allied health, or Tech Prep programs. This book was written for students who plan to learn a technical skill, but who have minimal background in mathematics or need considerable review. To become proficient in most technical programs, students must learn basic mathematical skills. To that end, Chapters 1 through 4 cover basic arithmetic operations, fractions, decimals, percent, the metric system, and numbers as measurements. Chapters 5 through 11 present essential algebra needed in technical and trade programs. The essentials of geometry—relationships and formulas for the most common two- and three-dimensional figures—are given in detail in Chapter 12. Chapters 13 and 14 present a short but intensive study of trigonometry that includes right-triangle trigonometry as well as oblique triangles and graphing. The concepts of statistics that are most important to technical fields are discussed in Chapter 15. An introduction to binary and hexadecimal numbers is found in Chapter 16 for those who requested this material.

This text is written to match the reading level of most technical students. Visual images engage these readers and stimulate the problem-solving process. These skills are essential for success in technical courses. This text is written to be as flexible as possible for the wide range of student backgrounds and technical program needs. Sections may be easily combined for the better prepared class of students.

The following important text features have been retained from previous editions:

- A large number of applications are used from a wide variety of technical areas, including agriculture and horticulture, allied health, auto/diesel service, aviation, business and personal finance, CAD/drafting, culinary arts, electronics, HVAC, industrial and construction trades, manufacturing, natural resources, and welding.
- Chapter 1 reviews basic concepts in such a way that individuals, groups of students, or the entire class can easily study only those sections they need to review.
- A comprehensive introduction to basic algebra is presented for those students who need it as a prerequisite to more advanced algebra courses. However, the book has been written to allow the omission of selected sections or chapters without loss of continuity, to meet the needs of specific students.
- More than 6500 exercises assist student learning of skills and concepts.
- More than 750 detailed, well-illustrated examples, many with step-by-step comments, support student understanding of skills and concepts.
- Learning objectives are listed with each Chapter Opener to give a clear outline of topics covered in the chapter. This serves as a reference for students when completing homework assignments or studying for exams, and it also helps with lesson and assessment preparation for instructors.

- A chapter summary with a glossary of basic terms, a chapter review, and a chapter test appear at the end of each chapter as aids for students in preparing for quizzes and exams. Each chapter test is designed to be completed by an average student in no more than approximately 50 minutes.

REVIEW | CHAPTER 3

Give the metric prefix for each value:

1. 0.001 **2.** 1000

Give the SI abbreviation for each prefix:

3. mega **4.** micro

Write the SI abbreviation for each quantity:

5. 42 millilitres **6.** 8.3 nanoseconds

Write the SI unit for each abbreviation:

7. 18 km **8.** 350 mA **9.** 50 μs

Which is larger?

10. 1 L or 1 mL **11.** 1 kW or 1 MW

12. 1 km^2 or 1 ha **13.** 1 m^3 or 1 L

Fill in each blank:

14. 650 m = _____ km **15.** 750 mL = _____ L

16. 6.1 kg = _____ g **17.** 4.2 A = _____ μA

27. Water boils at _____ °C.

28. 180 lb = _____ kg **29.** 126 ft = _____ m

30. 360 cm = _____ in. **31.** 275 in^2 = _____ cm^2

32. 18 yd^2 = _____ ft^2 **33.** 5 m^3 = _____ ft^3

34. 15.0 acres = _____ ha

Choose the most reasonable quantity:

35. Jorge and Maria drive **a.** 1600 cm, **b.** 470 m, **c.** 12 km, or **d.** 2400 mm to college each day.

36. Chuck's mass is **a.** 80 kg, **b.** 175 kg, **c.** 14 μg, or **d.** 160 Mg.

37. An automobile's fuel tank holds **a.** 18 L, **b.** 15 kL, **c.** 240 mL, or **d.** 60 L of gasoline.

38. Jamilla, being of average height, is **a.** 5.5 m, **b.** 325 mm, **c.** 55 cm, or **d.** 165 cm tall.

39. An automobile's average fuel consumption is **a.** 320 km/L, **b.** 15 km/L, **c.** 35 km/L, or **d.** 0.75 km/L.

TEST | CHAPTER 3

1. Give the metric prefix for 1000.

2. Give the metric prefix for 0.01.

3. Which is larger, 200 mg or 1 g?

4. Write the SI unit for the abbreviation 240 μL.

5. Write the abbreviation for 30 hectograms.

6. Which is longer, 1 km or 25 cm?

Fill in each blank:

7. 4.25 km = _____ m **8.** 7.28 mm = _____ μm

9. 72 m = _____ mm **10.** 256 hm = _____ cm

11. 12 dg = _____ mg **12.** 16.2 g = _____ mg

13. 7.236 metric tons = _____ kg

14. 310 g = _____ cg **15.** 72 hg = _____ mg

16. 1.52 dL = _____ L **17.** 175 L = _____ m^3

18. 2.7 m^3 = _____ cm^3 **19.** 400 ha = _____ km^2

20. 0.2 L = _____ mL

21. What is the basic SI unit of time?

22. Write the abbreviation for 25 kilowatts.

Fill in each blank:

23. 280 W = _____ kW **24.** 13.9 mA = _____ A

25. 720 ps = _____ ns

26. What is the basic SI unit for temperature?

27. What is the freezing temperature of water on the Celsius scale?

Fill in each blank, rounding each result to three significant digits when necessary:

28. 25°C = _____ °F **29.** 28°F = _____ °C

30. 98.6°F = _____ °C **31.** 100 km = _____ mi

32. 200 cm = _____ in. **33.** 1.8 ft^3 = _____ in^3

34. 37.8 ha = _____ acres **35.** 80.2 kg = _____ lb

- The text design and second color help to make the text more easily understood, highlight important concepts, and enhance the art presentation.
- A reference of useful, frequently referenced information—such as metric system prefixes, U.S. weights and measures, metric and U.S. conversion, and formulas from geometry—is printed on the inside covers.

- The use of a basic scientific calculator has been integrated in an easy-to-use format with calculator flowcharts and displays throughout the text to reflect its nearly universal use in technical classes and on the job. The instructor should inform the students when *not* to use a calculator.

Using a Calculator to Multiply and Divide Fractions

Example 16 Multiply: $2\frac{5}{6} \times 4\frac{1}{2}$.

2 A⅝ 5 A⅝ 6 × 4 A⅝ 1 A⅝ 2 =

12 3/4

Thus, $2\frac{5}{6} \times 4\frac{1}{2} = 12\frac{3}{4}$. ◆

Example 17 Divide: $5\frac{5}{7} \div 8\frac{1}{3}$.

5 A⅝ 5 A⅝ 7 ÷ 8 A⅝ 1 A⅝ 3 =

24/35

Thus, $5\frac{5}{7} \div 8\frac{1}{3} = \frac{24}{35}$. ◆

- Cumulative reviews are provided at the end of every even-numbered chapter to help students review for comprehensive exams.

CUMULATIVE REVIEW | CHAPTERS 1–6

1. Find the prime factorization of 696.
2. Change 0.081 to a percent.
3. Write 3.015×10^{-4} in decimal form.
4. Write 28,500 in scientific notation.
5. 5 ha = _____ m^2
6. 101°F = _____ °C
7. 6250 in^2 = _____ ft^2
8. Give the number of significant digits (accuracy) of each measurement:
   a. 110 cm **b.** 6000 mi **c.** 24.005 s
9. Read the measurement shown on the vernier caliper in Illustration 1 **a.** in metric units and **b.** in U.S. units.

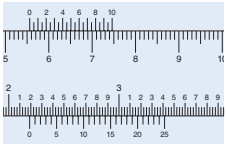

ILLUSTRATION 1

10. Read the measurement shown on the U.S. micrometer in Illustration 2.

Simplify:

12. $(2x - 5y) + (3y - 4x) - 2(3x - 5y)$
13. $(4y^3 + 3y - 5) - (2y^3 - 4y^2 - 2y + 6)$
14. $(3y^3)^3$
15. $-2x(x^2 - 3x + 4)$
16. $(6y^3 - 5y^2 - y + 2)(2y - 1)$
17. $(4x - 3y)(5x + 2y)$
18. $\frac{215\,x^2y^3}{45x^3y^5}$
19. $(16x^2y^3)(-5x^4y^5)$
20. $\frac{x^3 + 2x^2 - 11x - 20}{x + 5}$
21. $3x^2 - 4xy + 5y^2 - (-3x^2) + (-7xy) + 10y^2$

Solve:

22. $4x - 2 = 12$
23. $\frac{x}{4} - 5 = 9$
24. $4x - 3 = 7x + 15$
25. $\frac{5x}{8} = \frac{3}{2}$
26. $5 - (x - 3) = (2 + x) - 5$
27. $C = \frac{1}{2}(a + b + c)$ for a

- Studies show that current students will experience several career changes during their working lives. The chapter-opening pages illustrate various career paths for students to consider as their careers, technology, and the workplace evolve. The basic information provided in the chapter openers about a technical career is explored in further detail on the Cengage book companion website at www.cengage.com/mathematics/ewen.

Mathematics at Work

Electronics technicians perform a variety of jobs. Electronic engineering technicians apply electrical and electronic theory and knowledge to design, build, test, repair, and modify experimental and production electrical equipment in industrial or commercial plants for use by engineering personnel in making engineering design and evaluation decisions.

Andrey_Popov/Shutterstock.com

Electronics Technician
Electronics technician checking a fuse box

Other electronics technicians repair electronic equipment such as industrial controls, telemetering and missile control systems, radar systems, and transmitters and antennas using testing instruments. Industrial controls automatically monitor and direct production processes on the factory floor. Transmitters and antennas provide communications links for many organizations. The federal government uses radar and missile control systems for national defense as well as other applications.

Electricians install, maintain, and repair wiring, equipment, and fixtures and ensure that work is in accordance with relevant codes. They also travel to locations to repair equipment and perform preventive maintenance on a regular basis. They use schematics and manufacturers' specifications that show connections and provide instructions on how to locate problems. They also use software programs and testing equipment to diagnose malfunctions. For more information, please visit **www.cengagebrain.com** and access the Student Online Resources for this text.

- Special application exercises in the areas of agriculture and horticulture, allied health, auto/diesel service, aviation, business and personal finance, CAD/drafting, culinary arts, electronics, HVAC, industrial and construction trades, manufacturing, natural resources, and welding have been submitted by faculty in these technical areas and are marked with related icons.

44. Find the total piston displacement of a six-cylinder engine if each piston displaces 0.9 litres (L).

45. A four-cylinder engine has a total displacement of 2.0 L. Find the displacement of each piston.

46. An eight-cylinder engine has a total displacement of 318 in^3. Find the displacement of each piston.

47. New front brake pads are 0.375 in. thick. The average wear rate of these pads in a particular vehicle is 0.062 in. per 15,000 mi. Determine **a.** the expected wear after 45,000 mi and **b.** the expected pad thickness after 60,000 mi.

48. A certain job requires 500 person-hours to complete. How many days will it take for five people working 8 hours per day to complete the job?

49. How many gallons of herbicide are needed for 150 acres of soybeans if 1.6 gal/acre are applied?

50. Suppose 10 gal of water and 1.7 lb of pesticide are to be applied per acre. **a.** How much pesticide would you put in a 300-gal spray tank? **b.** How many acres can be covered with one tankful? (Assume the pesticide dissolves in the water and has no volume.)

51. A cattle feeder buys some feeder cattle, which average 550 lb at $145/hundredweight (that is, $145 per hundred pounds, or $1.45/lb). The price he receives when he sells them as slaughter cattle is $120/hundredweight. If he plans to make a profit of $150 per head, what will be his cost per pound for a 500-lb weight gain?

52. An insecticide is to be applied at a rate of 2 pt/100 gal of water. How many pints are needed for a tank that holds 20 gal? 60 gal? 150 gal? 350 gal? (Assume that the insecticide dissolves in the water and has no volume.)

59. A lamp that requires 0.84 A of current is connected to a 115-V source. What is the lamp's resistance? (Resistance equals voltage divided by current.)

60. A heating element operates on a 115-V line. If it has a resistance of 18 Ω, what current does it draw? (Current equals voltage divided by resistance.)

61. A patient takes 3 tablets of clonidine hydrochloride, containing 0.1 mg each. How many milligrams are taken?

62. One dose of ampicillin for a patient with bronchitis is 2 tablets each containing 0.25 g of medication. How many grams are in one dose?

63. An order reads 0.5 mg of digitalis, and each tablet contains 0.1 mg. How many tablets should be given?

64. An order reads 1.25 mg of digoxin, and the tablets on hand are 0.25 mg. How many tablets should be given?

65. A statute mile is 5280 ft. A nautical mile used in aviation is 6080.6 ft. This gives the conversion 1 statute mile = 0.868 nautical miles. If a plane flew 350 statute miles, how many nautical miles were flown?

66. Five lathes and four milling machines are to be on one circuit. If each lathe uses 16.0 A and each milling machine uses 13.8 A, what is the amperage requirement for this circuit?

67. A steel plate 1.00 in. thick weighs 40.32 lb/ft^2. Find the weight of a 4.00 ft × 8.00 ft sheet.

68. Municipal solid waste (MSW) consists basically of trash and recycle that is produced by nonindustrial and nonagricultural sources. According to Environmental Protection Agency estimates, as of 2014, each person in the United States generated an average of 4.44 lb of MSW each day. If you are an average American, how

- Group activity projects have been moved to the Instructor Companion website.
- An instructor's edition that includes all the answers to exercises is available.

Significant changes in the twelfth edition include the following:

- New and revised applications with the help and expertise of professionals in the areas of industrial and construction trades, electronics, and CAD/drafting.
- All areas have been reviewed and updated with current information and data.
- The material on measurement has been reorganized and revised to provide better rationale for measurement accuracy and precision and for calculations with measurements. Single versus multiple measurements are compared, and the concept of random and systematic errors have been introduced.
- Major effort was made to contain cost to students by having a more space-efficient page design, reviewing art size and placement, moving Group Activities from the end of each chapter to the Instructor Companion website, and deleting dial indicator material from Section 4.9 that seemingly was not being used.
- More than 140 exercises have been updated, replaced, or improved.

Useful ancillaries available to qualified adopters of this text include the following:

WEBASSIGN From Cengage www.webassign.com/cengage

- WebAssign from Cengage *Elementary Technical Mathematics*, Twelfth Edition, is a fully customizable online solution for STEM disciplines that empowers you to help your students learn, not just do homework. Insightful tools save you time and highlight exactly where your students are struggling. Decide when and what type of help students can access while working on assignments—and incentivize independent work so help features aren't abused. Meanwhile, your students get an engaging experience, instant feedback, and better outcomes. A total win-win!

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- **Instructor Solutions Manual** (ISBN: 978-1-337-63063-4): This guide contains solutions to every exercise in the book. You can download the solutions manual from the Instructor Companion Site.
- **Instructor Companion Website:** Everything you need for your course in one place! Access the Instructor Solutions Manual, full lecture PowerPoints, Group Projects, and other support materials. This collection of book-specific lecture and class tools is available via www.cengage.com/login

Student Resources:

WEBASSIGN From Cengage www.webassign.com

- Prepare for class with confidence using WebAssign from Cengage *Elementary Technical Mathematics*, Twelfth Edition. This online learning platform fuels practice, so you truly absorb what you learn—and are better prepared come test time. Videos and tutorials walk you through concepts and deliver instant feedback and grading, so you always know where you stand in class. Focus your study time and get extra practice where you need it most. Study smarter with WebAssign!

  Ask your instructor today how you can get access to WebAssign, or learn about self-study options at www.webassign.com

- **Student Solutions Manual**
  Author: James Lapp
  (ISBN: 978-1-337-63060-3)
  The Student Solutions Manual provides worked-out solutions to all of the odd-numbered exercises in the text, as well as solutions to all chapter review and cumulative review exercises.

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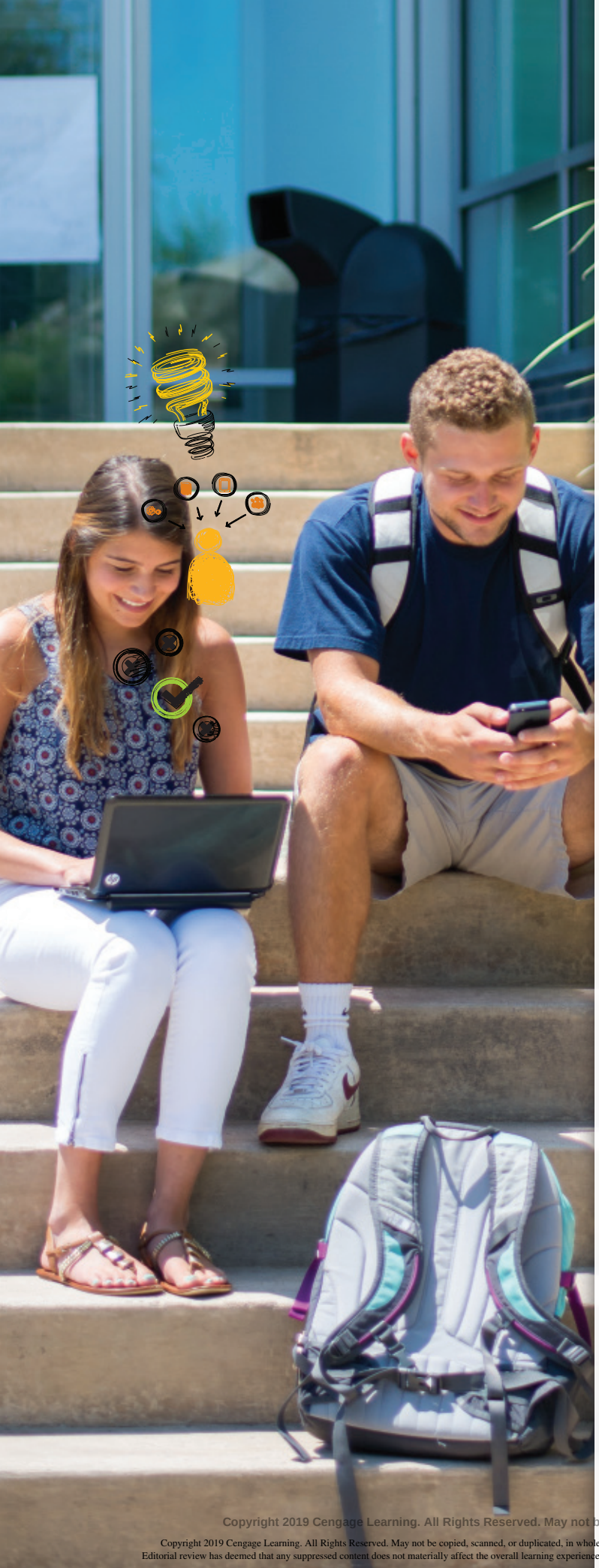
Dale Ewen



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Basic Concepts

CHAPTER 1

OBJECTIVES

- Add, subtract, multiply, and divide whole numbers.
- Add, subtract, multiply, and divide whole numbers with a basic scientific calculator.
- Apply the rules for order of operations.
- Find the area and volume of geometric figures.
- Evaluate formulas.
- Find the prime factorization of whole numbers.
- Add, subtract, multiply, and divide fractions.
- Add, subtract, multiply, and divide fractions with a basic scientific calculator.
- Use conversion factors to change from one unit to another within the U.S. system of weights and measures.
- Add, subtract, multiply, and divide decimal fractions.
- Add, subtract, multiply, and divide decimal fractions with a basic scientific calculator.
- Round numbers to a particular place value.
- Apply the percent concept; change a percent to a decimal, a decimal to a percent, a fraction to a percent, and a percent to a fraction.
- Solve application problems involving the addition, subtraction, multiplication, and division of whole numbers, fractions, and decimal fractions and percents.
- Find powers and roots of numbers using a scientific calculator.
- Solve personal finance problems involving percent.

Mathematics at Work

Modern manufacturing companies require a wide variety of technology specialists for their operations. Manufacturing technology specialists set up, operate, and maintain industrial and manufacturing equipment as well as computer-numeric-controlled (CNC) and other automated equipment that make a large variety of products according to controlled specifications. Some focus on systematic equipment maintenance and repair. Others specialize in materials transportation and distribution; that is, they are responsible for moving and distributing the products to the sales locations and/or consumers after they are manufactured. Other key team members include designers, engineers, draftspersons, and quality control specialists. Training and education for these careers are available at many community colleges and trade schools. Some require a bachelor's degree. For more information, please visit **www.cengagebrain.com** and access the Student Online Resources for this text.

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Manufacturing Technology Specialist
Technician working with numerically controlled milling machine

UNIT 1A Review of Operations with Whole Numbers

1.1 Review of Basic Operations

The **positive integers** are the numbers 1, 2, 3, 4, 5, 6, and so on. They can also be written as +1, +2, +3, and so on, but usually the *positive* (+) sign is omitted. The **whole numbers** are the numbers 0, 1, 2, 3, 4, 5, 6, and so on. That is, the whole numbers consist of the positive integers and zero.

The value of any digit in a number is determined by its place in the particular number. Each place represents a certain power of 10. By powers of 10, we mean the following:

$10^0 = 1$
$10^1 = 10$
$10^2 = 10 \times 10 = 100$ (the second power of 10)
$10^3 = 10 \times 10 \times 10 = 1000$ (the third power of 10)
$10^4 = 10 \times 10 \times 10 \times 10 = 10{,}000$ (the fourth power of 10) and so on.

NOTE: A small superscript number (such as the 2 in 10^2) is called an *exponent*.

The number 2354 means 2 thousands plus 3 hundreds plus 5 tens plus 4 ones.

In the number 236,895,174, each digit has been multiplied by some power of 10, as shown below.

(ten millions)		(hundred thousands)		(thousands)		(tens)	
10^7		10^5		10^3		10^1	
2	3	6,	8	9	5,	1	7	4
10^8		10^6		10^4		10^2		10^0
(hundred millions)		(millions)		(ten thousands)		(hundreds)		(units)

The "+" (plus) symbol is the sign for addition, as in the expression 5 + 7. The result of adding the numbers (in this case, 12) is called the **sum**. Integers are added in columns with the digits representing like powers of 10 in the same vertical line. (*Vertical* means up and down.)

Example 1 Add: 238 + 15 + 9 + 3564.

$$\begin{array}{r} 238 \\ 15 \\ 9 \\ \underline{3564} \\ 3826 \end{array}$$

♦

Subtraction is the inverse operation of addition. Therefore, subtraction can be thought of in terms of addition. The "−" (minus) sign is the symbol for subtraction. The quantity 5 − 3 can be thought of as "what number added to 3 gives 5?" The result of subtraction is called the **difference**.

To check a subtraction, add the difference to the second number. If the sum is equal to the first number, the subtraction has been done correctly.

Example 2 Subtract: 2843 − 1928.

Subtract:

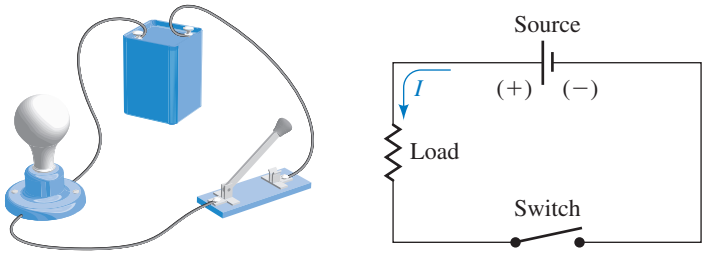
2843	first number
−1928	second number
915	difference

Check:

1928	second number
+915	difference
2843	This sum equals the first number, so 915 is the correct difference.

◆

Next, let's study some applications. To communicate about problems in electricity, technicians have developed a "language" of their own. It is a picture language that uses symbols and diagrams. The symbols used most often are listed in Table 2 of Appendix A. An electric circuit is a conducting loop in which electrons carrying electric energy may be transferred from a source to do useful work and returned to the source. The circuit diagram is the most common and useful way to show an electric circuit. Note how each component (part) of the picture (Figure 1.1a) is represented by its symbol in the circuit diagram (Figure 1.1b) in the same relative position.



(a) Picture diagram **(b)** Circuit diagram

Figure 1.1
Components in an electric circuit

The light bulb may be represented as a resistance. Then the circuit diagram in Figure 1.1b would appear as in Figure 1.2, where

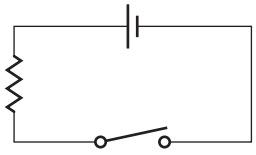
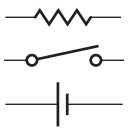


Figure 1.2



represents the resistor

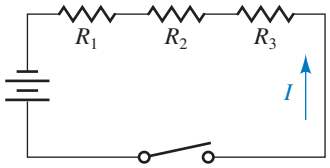
represents the switch

represents the source. The short line represents the negative terminal of a battery, and the long line represents the positive terminal. The current flows from positive to negative.

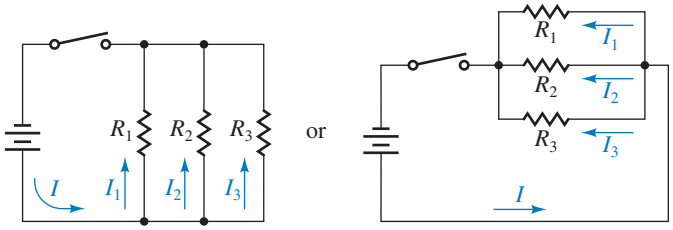
Energy is stored in the battery. When the switch is closed, energy is transferred to the light, and the light glows.

NOTE: In this book assume that the charge carriers are positive and draw current arrows in the direction that a positive charge would flow. This is a common practice used by most technicians and engineers. However, you may find the negative-charge–current-flow convention is also used in some books. Regardless of the convention used, the formulas and results are the same.

There are two basic types of electric circuits: series and parallel. An electric circuit with only one path for the current, I, to flow is called a *series* circuit (Figure 1.3a). An electric circuit with more than one path for the current to flow is called a *parallel* circuit (Figure 1.3b). A circuit breaker or fuse in a house is wired in series with its outlets. The outlets themselves are wired in parallel.



(a) Series circuit



(b) Parallel circuits

Figure 1.3
Two basic types of electric circuits

Example 3 In a series circuit, the total resistance equals the sum of all the resistances in the circuit. Find the total resistance in the series circuit in Figure 1.4. Resistance is measured in ohms, Ω.

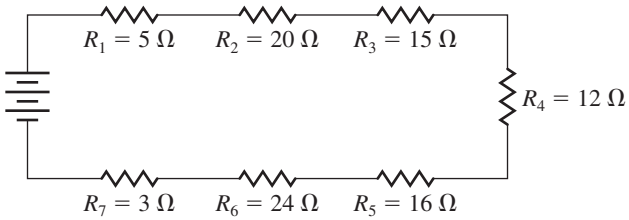


Figure 1.4

The total resistance is

$$\begin{array}{r} 5\ \Omega \\ 20\ \Omega \\ 15\ \Omega \\ 12\ \Omega \\ 16\ \Omega \\ 24\ \Omega \\ 3\ \Omega \\ \hline 95\ \Omega \end{array}$$

♦

Example 4 Studs are upright wooden or metal pieces in the walls of a building, to which siding, insulation panels, drywall, or decorative paneling is attached. (A wall portion with seven studs is shown in Figure 1.5.) Studs are normally placed 16 in. on center and are placed double at all internal and external corners of a building. The number of studs needed in a wall can be estimated by finding the number of linear feet (ft) of the wall. How many studs are needed for the exterior walls of the building in Figure 1.6?

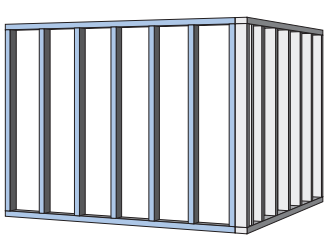


Figure 1.5

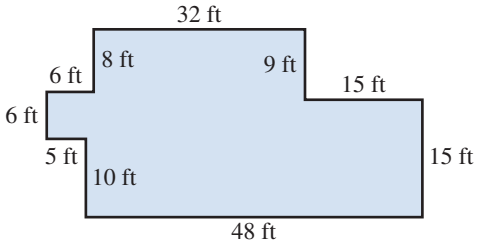


Figure 1.6

The outside perimeter of the building is the sum of the lengths of the sides of the building:

$$\begin{array}{r} 48 \text{ ft} \\ 15 \text{ ft} \\ 15 \text{ ft} \\ 9 \text{ ft} \\ 32 \text{ ft} \\ 8 \text{ ft} \\ 6 \text{ ft} \\ 6 \text{ ft} \\ 5 \text{ ft} \\ \underline{10 \text{ ft}} \\ 154 \text{ ft} \end{array}$$

Therefore, approximately 154 studs are needed in the outside wall. ♦

Repeated addition of the same number can be shortened by multiplication. The "×" (times) and the "·" (raised dot) are used to indicate multiplication. When adding the lengths of five pipes, each 7 ft long, we have 7 ft + 7 ft + 7 ft + 7 ft + 7 ft = 35 ft of pipe. In multiplication, this would be 5×7 ft = 35 ft. The 5 and 7 are called *factors*. The result of multiplying numbers (in this case, 35) is called the **product**. Computing areas, volumes, forces, and distances requires skills in multiplication.

Example 5 Multiply: 358×18.

$$\begin{array}{r} 358 \\ \times\ 18 \\ \hline 2864 \\ \underline{358\ } \\ 6444 \end{array}$$

♦

Division is the inverse operation of multiplication. The following symbols are used to show division: $15 \div 5$, $5\overline{)15}$, 15/5, and $\frac{15}{5}$. The quantity $15 \div 5$ can also be thought of as "what number times 5 gives 15?" The answer to this question is 3, which is 15 divided by 5. The result of dividing numbers (in this case, 3) is called the **quotient**. The number to be divided, 15, is called the *dividend*. The number you divide by, 5, is called the *divisor*.

Example 6 Divide: $84 \div 6$.

$$\begin{array}{rl} 14 & \leftarrow \text{quotient} \\ 6\overline{)84} & \leftarrow \text{dividend} \\ \text{divisor} \uparrow\ 6 & \\ \overline{24} & \\ \underline{24} & \\ 0 & \leftarrow \text{remainder} \end{array}$$

♦

Example 7 Divide: $115 \div 7$.

$$\begin{array}{rl} 16 & \leftarrow \text{quotient} \\ 7\overline{)115} & \leftarrow \text{dividend} \\ \text{divisor} \uparrow\ 7 & \\ \overline{45} & \\ \underline{42} & \\ 3 & \leftarrow \text{remainder} \end{array}$$

♦

The *remainder* (when not 0) is usually written in one of two ways: with an "r" preceding it or with the remainder written over the divisor as a fraction, as shown in Example 8. (Fractions are discussed in Unit 1B.)

Example 8 Divide: 534 ÷ 24.

$$24\overline{)534}\quad 22 \text{ r } 6 \quad \text{or} \quad 22\tfrac{6}{24}$$

This quotient may be written 22 r 6 or $22\frac{6}{24}$.

$$\begin{array}{r} 48 \\ \hline 54 \\ 48 \\ \hline 6 \end{array}$$

◆

Example 9 Ohm's law states that in a simple electric circuit, the current I (measured in amps, A) equals the voltage E (measured in volts, V) divided by the resistance R (measured in ohms, Ω). Find the current in the circuit of Figure 1.7.

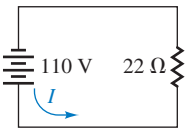


Figure 1.7

The current $I = \dfrac{E}{R} = \dfrac{110}{22} = 5$ A. ◆

Example 10 A 16-row corn planter costs $128,500. It has a 10-year life and a salvage value of $10,000. What is the annual depreciation? (Use the straight-line depreciation method.)

The straight-line depreciation method means that the difference between the cost and the salvage value is divided evenly over the life of the item. In this case, the difference between the cost and the salvage value is

$128,500	cost
−$10,000	salvage
$118,500	difference

This difference divided by 10, the life of the item, is $11,850. This is the annual depreciation. ◆

Example 11 Restaurants purchase potatoes to use for baked potatoes. The potatoes are often called bakers and can come in cases containing 90, 120, and so on, potatoes. If 3 cases of bakers with 90 potatoes per case are ordered plus 2 cases of bakers with 120 potatoes per case, how many total individual bakers are ordered?

3 cases × 90 potatoes/case	= 270 potatoes
2 cases × 120 potatoes/case	= 240 potatoes
Total	510 potatoes

◆

Using a Scientific Calculator

Use of a scientific calculator is integrated throughout this text. To demonstrate how to use a common scientific calculator, we show which keys to use and the order in which they are pushed. We have chosen to illustrate the most common types of algebraic logic calculators. Yours may differ. If so, consult your manual.

NOTE: Your calculator should be cleared before you begin any calculation.

Use a calculator to add, subtract, multiply, and divide as shown in the following examples.

Example 12 Add: 9463
125
9
80

9463 [+] 125 [+] 9 [+] 80 [=]

9677

The sum is 9677. ◆

Example 13 Subtract: 3500
1628

3500 [−] 1628 [=]

1872

The result is 1872. ◆

Example 14 Multiply: 125×68.

125 [×] 68 [=]

8500

The product is 8500. ◆

Example 15 Divide: $8700 \div 15$.

8700 [÷] 15 [=]

580

The quotient is 580. ◆

NOTE: Your instructor will indicate which exercises should be completed using a calculator.

EXERCISES 1.1

Add:

1. 832 + 9 + 56 + 2358

2. 324 + 973 + 66 + 9430

3.
384
291
147
632

4.
78
107
45
217
9
123

5. 197 + 1072 + 10,877 + 15,532 + 768,098

6. 160,000 + 19,000 + 4,160,000 + 506,000

Subtract and check:

7.
7561
2397

8.
4000
702

9. 98,405 − 72,397

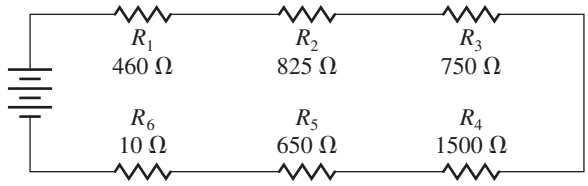
10. 417,286 − 287,156

11.
4000
1180

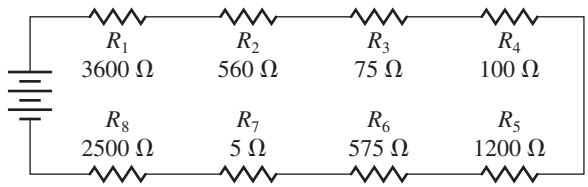
12.
60,000
9,876

Find the total resistance in each series circuit:

13.



14.



15. Approximately how many studs are needed for the exterior walls in the building shown in Illustration 1? (See Example 4.)

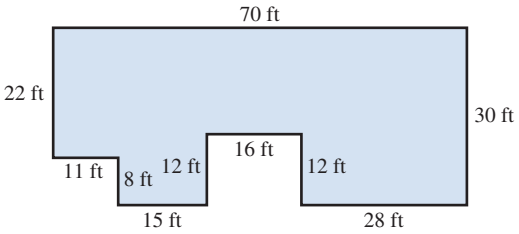


ILLUSTRATION 1

16. A pipe 24 ft long is cut into four pieces: the first 4 ft long, the second 5 ft long, and the third 7 ft long. What is the length of the remaining piece? (Assume no waste from cutting.)

17. A welder needs to weld together pipes of lengths 10 ft, 15 ft, and 14 ft. What is the total length of the new pipe?

18. A welder ordered a 125-ft^3 cylinder of argon gas, a semi-inert shielding gas for TIG welding. After a few days, only 78 ft^3 remained. How much argon was used?

19. Find the total input and output (I-O) in cubic centimetres (cm^3)* for a patient. By how much does the input of fluids exceed the output?

Input: 300 cm^3, 550 cm^3, 150 cm^3, 75 cm^3, 150 cm^3, 450 cm^3, 250 cm^3
Output: 325 cm^3, 150 cm^3, 525 cm^3, 250 cm^3, 175 cm^3

20. A student pilot must complete 40 h of total flight time as required for her private pilot certificate. She had already entered 31 h of flight time in her logbook. Monday she logged another 2 h, then Wednesday she logged another 3 h, and Friday she logged yet another 2 h. If she can fly 3 h more on Saturday, will she have enough total time as required for the certificate?

Multiply:

21. $\begin{array}{r} 567 \\ \times\ 48 \end{array}$

22. $\begin{array}{r} 8374 \\ \times\ 203 \end{array}$

23. $71{,}263 \times 255$

24. 1520×320

25. 6800×5200

26. $30{,}010 \times 4080$

Divide (use the remainder form with r):

27. $4\overline{)7236}$

28. $5\overline{)308{,}736}$

29. $4668 \div 12$

30. $15{,}648 \div 36$

31. $67{,}560 \div 80$

32. $\dfrac{188{,}000}{120}$

33. An automobile uses gasoline at the rate of 31 miles per gallon (mi/gal or mpg) and has a 16-gallon tank. How far can it travel on one tank of gas?

34. An automobile uses gasoline at a rate of 12 kilometres per litre (km/L) and has a 65-litre tank. How far can it travel on one tank of gas?

35. A four-cylinder engine has a total displacement of 1300 cm^3. Find the displacement of each piston.

36. An automobile travels 1274 mi and uses 49 gal of gasoline. Find its mileage in miles per gallon.

37. An automobile travels 2340 km and uses 180 L of gasoline. Find its fuel consumption in kilometres per litre.

38. To replace some damaged ductwork, 20 linear feet of 8-in. × 16-in. duct is needed. The cost is $13 per 4 linear feet. What is the cost of replacement?

39. The bill for a new transmission was received. The total cost for labor was $516. If the car was serviced for 6 h, find the cost of labor per hour.

40. The cost for a set of four tires is $596. What is the cost of each tire?

41. A small Cessna aircraft has enough fuel to fly for 4 h. If the aircraft cruises at a ground speed of 125 miles per hour (mi/h or mph), how many miles can the aircraft fly in the 4 h?

42. A small plane takes off and climbs at a rate of 500 ft/min. If the plane levels off after 15 min, how high is the plane?

*Although cm^3 is the "official" metric abbreviation for cubic centimetres and will be used throughout this book, some readers may be more familiar with the abbreviation "cc," which is still used in some medical and allied health areas.

43. Inventory shows the following lengths of 3-inch steel pipe:

5 pieces 18 ft long
42 pieces 15 ft long
158 pieces 12 ft long
105 pieces 10 ft long
79 pieces 8 ft long
87 pieces 6 ft long

What is the total linear feet of pipe in inventory?

44. An order of lumber contains 36 boards 12 ft long, 28 boards 10 ft long, 36 boards 8 ft long, and 12 boards 16 ft long. How many boards are contained in the order? How many linear feet of lumber are contained in the order?

45. Two draftspersons, operating the same computer plotter, each work 8 hours per day. One produces 80 drawings per hour; the other produces 120 drawings per hour. What is the difference in their outputs after 30 work days?

46. A shipment contains a total of 5232 linear feet of steel pipe. Each piece of pipe is 12 ft long. How many pieces should be expected?

47. The wall is 10 ft high and the vertical length of the window is 54 in. The center of the window needs to be at a distance of 5/8 of the height of the wall above the floor (to meet the special Fibonacci ratio criteria). How should a window 75 in. wide be horizontally placed so that it is centered on a wall 17 ft 5 in. wide? How high is the bottom of the window above the floor?

48. A farmer expects a yield of 165 bushels per acre (bu/acre) from 260 acres of corn. If the corn is stored, how many bushels of storage are needed?

49. A farmer harvests 6864 bushels (bu) of soybeans from 156 acres. What is his yield per acre?

50. A railroad freight car can hold 2035 bu of corn. How many freight cars are needed to haul the expected 12,000,000 bu from a local grain elevator?

51. On a given day, eight steers weighed 856 lb, 754 lb, 1044 lb, 928 lb, 888 lb, 734 lb, 953 lb, and 891 lb. **a.** What is the average weight? **b.** In 36 days, 4320 lb of feed is consumed. What is the average feed consumption per day per steer?

52. What is the weight (in tons) of a stack of hay bales 6 bales wide, 110 bales long, and 15 bales high? The average weight of each bale is 80 lb. (1 ton = 2000 lb.)

53. From a 34-acre field, 92,480 lb of oats are harvested. Find the yield in bushels per acre. (1 bu of oats weighs 32 lb.)

54. A standard bale of cotton weighs approximately 500 lb. How many bales are contained in 15 tons of cotton?

55. A tractor costs $175,000. It has a 10-year life and a salvage value of $3000. What is the annual depreciation? (Use the straight-line depreciation method. See Example 10.)

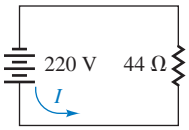
56. How much pesticide powder would you put in a 400-gal spray tank if 10 gal of spray, containing 2 lb of pesticide, are applied per acre?

57. Daylilies are to be planted along one side of a 30-ft walk in front of a house. The daylilies are planted 5 in. from each end and 10 in. apart along the walk. How many daylilies are needed?

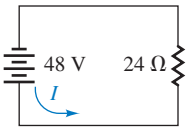
58. A potato patch has 7 rows with 75 hills of potatoes per row. If each potato hill yields 3 lb of marketable potatoes, how many pounds of marketable potatoes were produced?

Using Ohm's law, find the current I in amps (A) in each electric circuit (see Example 9):

59.

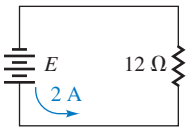


60.

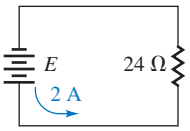


Ohm's law, in another form, states that in a simple circuit the voltage E (measured in volts, V) equals the current I (measured in amps, A) times the resistance R (measured in ohms, Ω). Find the voltage E measured in volts (V) in each electric circuit:

61.



62.



63. A hospital dietitian determines that each patient needs 4 ounces (oz) of orange juice. How many ounces of orange juice must be prepared for 220 patients?

64. During 24 hours, a patient is to receive three 60-mg doses of phenobarbital. Each tablet contains 30 mg of phenobarbital. How many milligrams of phenobarbital does the patient receive altogether in 24 hours? How many pills does the patient take in 24 hours?