Medical Dosage Calculations

A Dimensional Analysis Approach

UPDATED ELEVENTH EDITION

Anthony Patrick Giangrasso • Dolores Donahue Shrimpton

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Updated Eleventh Edition

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About the Authors

Anthony Giangrasso was born and raised in Maspeth, New York. He attended Rice High School on a scholarship, and in his senior year was named in an annual citywide contest by the *New York Journal-American* newspaper as New York City's most outstanding high school scholar-athlete. He was also awarded a full-tuition scholarship to Iona College, from which he obtained a BA in mathematics, magna cum laude, ranking sixth in his graduating class of approximately 600 students.

Anthony began his teaching career as a fifth-grade teacher in Manhattan, as a member of the Christian Brothers of Ireland, and taught high school mathematics and physics in Harlem and Newark, New Jersey. He holds an MS and PhD from New York University and has taught at all levels from elementary through graduate school. He is currently teaching at LaGuardia Community College, where he was chairman of the mathematics department. He has authored nine college textbooks through twenty-eight editions with over two million copies sold.

Anthony's community service has included membership on the boards of directors of the *Polish-American Museum Foundation, Catholic Adoptive Parents Association,* and *Family Focus Adoptive Services.* He was the *founding Chairman of the Board* of the *Italian-American Legal Defense and Higher Education Fund, Inc.,* and the *president of the Italian-American Faculty Association of the City University of New York.*

He and his wife, Susan, are proud parents of Anthony (Sasha), Michael (Victoria), and Jennifer (Ryan)—and grandparents of Calvin, Jackson, Isabel, and Emilia. He enjoys tennis and twice has been ranked #1 for his age group in the Eastern Section by the *United States Tennis Association*.

Dedication

For my lovely wife, Susan. Thanks for your love and inspiration for over five decades.

—Anthony Giangrasso

Dolores Shrimpton is a graduate of Kings County Hospital Center School of Nursing and received a BS from Long Island University, CW Post College, Major Nursing; a Master's Degree from New York University, Major Nursing Administration; and a Post Master's Certificate in Nursing Education from Adelphi University. Dolores is a member of Sigma Theta Tau International, Upsilon and Mu Upsilon chapters and NACLI.

Dolores has been a nurse educator in Diploma, ADN and LPN nursing programs. She has taught Fundamentals, Geriatrics, Med-Surg I, Pediatrics, Maternity and Issues in Nursing. Additionally, she has taught NCLEX- RN review courses in NY, CT, and Puerto Rico. She retired from Kingsborough Community College, after 28 years. During that time, she was Professor and Chairperson of the Department of Nursing for 13 years. She has co-authored three college nursing books through nine editions.

She has held many leadership positions in nursing, including Board member, Vice-President, and President of the NYS Associate Degree Nursing Council. She was the Co-Chair of the CUNY Nursing Discipline Council and Member of the Board of Directors, and Co-President of the Brooklyn Nursing Partnership.

Dolores is a recipient of the NACLI Presidential Award in Nursing Leadership, and the 2018 Ruth W. Harper Award, as well as the Mu Upsilon award for Excellence in Nursing Education and Excellence in Nursing Leadership. She has also been recognized for her commitment to nursing by the Brooklyn Nursing Partnership.

As an administrator, educator, author, scholar and public servant Dolores has remained dedicated to the nursing profession and the public it serves. She now lives in Rockville Centre, New York, and enjoys cooking and spending time with her grandchildren, Brooke Elizabeth, Paige Dolores, Jack Paul and their parents, Kim and Shawn. She also enjoys traveling and spending time with friends and family at her home in Harwich Port, Cape Cod Massachusetts.

Dedication

For my oldest and dearest friend Rose Anne Wands-Welcome to the 70's! "Oh the places we've gone and the things we've done"!!

For the Kings County Hospital Center School of Nursing Class of 1969—where have the past 50 years gone! Missing those who are no longer with us, especially my roommate Dr. Margaret (Peggy) Doell Budnik.

Congratulations to Brooke Elizabeth Shrimpton on your 18th birthday and graduation from high school. So very proud of you in all your accomplishments and as you set off to college in your pursuit to become a veterinarian. "… remember that Life's a Great Balancing Act. . . . Oh the places you'll go and the things you'll do" !!!

—Dolores Donahue Shrimpton

Preface

Safe administration of medication starts with equipping future healthcare professionals with the requisite mathematics skills. Recent studies show that medical errors result in 400,000 patient deaths per year (MacDonald, 2013), 35% of which are due to medication errors (James, 2013). Approximately 75% of novices commit medication errors. "Each year, in the United States alone, 7,000 to 9,000 people die as a result of a medication error. Additionally, hundreds of thousands of other patients experience but often do not report an adverse reaction or other medication complications. The total cost of looking after patients with medication-associated errors exceeds $40 billion each year. In addition to the monetary cost, patients experience psychological and physical pain and suffering as a result of medication errors. Finally, a major consequence of medication errors is that it leads to decreased patients satisfaction and a growing lack of trust in the healthcare system." ("http://www.statpearls.com"). Calculating and administering correct dosages is a crucial skill.

Many nursing students dread mathematics. Teaching dosage calculations to an audience with a fear of the subject can be daunting. A student with a preconceived notion that "math is difficult" has his/her ability to learn the subject severely obstructed. Dimensional Analysis helps develop a number sense, and largely frees the student from the need to memorize formulas. Once Dimensional Analysis is mastered, students will be able to calculate drug dosages quickly and safely.

Students need accessible resources that provide easy-to-understand instructions and explanations, progressively more challenging examples, and many practice problems in order to progress. The updated eleventh edition of *Medical Dosage Calculations: A Dimensional Analysis Approach* coupled with *MyLab Nursing for Dosage Calculations* helps students develop dosage calculation skills and transfer those skills to the administration of medication safely in a clinical environment.

Today, safety is a primary concern in medication administration. One aspect of that safety is accuracy in drug calculations. Calculation skills and the rationales behind them are emphasized throughout this textbook. *Medical Dosage Calculations* is not merely a textbook about mathematics skills; it is also an introduction to the professional context of safe drug administration.

Medical Dosage Calculations is a combined text- and workbook. Its consistent focus on safety, accuracy, and professionalism make it a valuable part of a course for nursing and allied health programs. It is also highly effective for independent study, and may be used as a refresher for dosage calculation skills and as a professional reference.

We are proud to say that the introduction of this book in 1973 provided the first textbook for nursing students to employ the Dimensional Analysis approach. Almost immediately after its publication, many imitators sprang up; so that today in college classrooms across the United States, and worldwide. Dimensional Analysis is the most popular approach used.

Organization of Content

Divided into four units, *Medical Dosage Calculation* progresses from simple math topics to more complex ones. Based on the text's organization, *MyLab Nursing for Dosage Calculations* features practice activities and assessment opportunities to support and reinforce content.

Unit	Content
1: Basic Calculation Skills and Introduction to Medication Administration	Chapter 1 reviews basic math skills. Chapter 2 presents the medication administration process. Chapter 3 introduces the dimensional analysis method in small increments, step-by-step.
2: Systems of Measurement	Chapters 4 and 5 feature metric and household measurement systems needed to interpret medication orders and calculate dosages, with students learning to convert between and within measurement systems.
3: Oral and Parenteral Medications	Chapter 6 introduces oral drug dosage calculations and includes dosages based on patient size. Chapter 7 discusses syringes and insulin. Chapter 8 introduces solutions. Chapter 9 presents parenteral medications and heparin.

Unit	Content
Unit 4: Infusions and Pediatric Dosages	Chapters 10 and 11 teach how to calculate intravenous and enteral dosage rates, flow rates, IV push and titrating IV medications. Chapter 12 explains pediatric dosages and daily fluid maintenance.

New Features

- *MyLab Nursing for Dosage Calculations* provides diagnostic testing and practice opportunities with hundreds of questions. (Please speak to your Pearson Health Sciences Specialist about package options.)
- Highlights safety in medication administration per the Joint Commission National Patient Safety Goals, the Institute for Safe Medical Practice, and the CDC One and Only Campaign.
- Updates drug labels and examples for both trade and generic drug names.
- Expands coverage of titration tables and IV push.
- Provides latest information on insulin administration and calculations.
- Enhances coverage of heparin administration and calculations.
- Features schematic diagrams for computations concerning solutions, IVP, and IV calculations.
- Showcases new illustrated examples.

Hallmark Features

- Provides Calculator Keystroke Sequences in Chapter 1, enabling students to check their calculations.
- Enhances all illustrated examples with worked-out solutions, showing each step in the process.
- Reinforces skills through frequent practice opportunities, offering more than 1,000 problems for students to solve.
- Presents current drug labels, syringes, drug package inserts, prescriptions, and medication administration records (MARs).
- Includes answers in Appendix A to Try These for Practice, Exercises, Cumulative Review questions, and Case Studies making it easy for students to check their work. (Note: the Instructor's Resource Manual provides answers to the Additional Exercises.)

Student Resources

MyLab Nursing for Dosage Calculations

MyLab Nursing for Dosage Calculations enhances learning by providing diagnostic quizzing, practice exercises, and chapter assessments. Ask your Pearson Health Science Specialist for a demonstration, and to learn about packaging this powerful resource with the printed text.

- Mirrors *Medical Dosage Calculation: A Dimensional Analysis Approach's* organization.
- Helps students identify gaps in their knowledge by providing over 200 pre- and post-test diagnostic questions.
- Features 425 topic specific multiple choice practice exercises.
- Illustrates select questions with drug labels, package inserts, and syringe images.
- Offers automatic feedback with explanations to support learning.
- Includes access to eText of *Medical Dosage Calculation: A Dimensional Analysis Approach*.

Instructor Resources

Locate text-specific Instructor Resources in the *MyLab Nursing for Dosage Calculations* resource that can accompany *Medical Dosage Calculation: A Dimensional Analysis Approach* (see Instructor Tools section), and Pearson's Instructor Resource Center. Login credentials are required to access these ancillaries. Speak to your Pearson Health Sciences Specialist for assistance.

Instructor's Resource Manual provides an overview, instructor notes, answers to Additional Exercises in the book, exam questions and answers for every chapter.

Lecture Note PowerPoint features slides with instructions and worked examples to assist with classroom and online learning.

Test Item File contains questions that instructors can use to create tests. Conversion files also available for popular Learning Management Systems.

Acknowledgments

Our special thanks to the nursing and mathematics faculty and the students at LaGuardia Community College and Kingsborough Community College. Also, a special thank you to our product manager, John Goucher, and content producer, Michael Giacobbe, and to the marketing teams at Pearson.

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Learn to Calculate Dosages Safely and Accurately!

The Ease of Learning Dosage Calculations

Dosage Calculations provides the ease of learning the dimensional analysis method of calculation with a building-block approach of the basics.

Name: _____ Date: _____

Diagnostic Test of Arithmetic

The following Diagnostic Test illustrates *all* the arithmetic skills needed to do the computations in this textbook. Take the test and compare your answers with the answers found in Appendix A. If you discover areas of weakness, carefully review the relevant review materials in this chapter so that you will be mathematically prepared for the rest of the textbook.

1. Write 0.375 as a fraction in lowest terms. _____
2. Write $\frac{28{,}500}{100{,}000}$ as a decimal number. _____
3. Round off 6.492 to the nearest tenth. _____
4. Write $\frac{5}{6}$ as a decimal number rounded off to the nearest hundredth. _____
5. Simplify $\frac{0.63}{0.2}$ to a decimal number rounded off to the nearest tenth. _____
6. $0.038 \times 100 =$ _____
7. $4.26 \times 0.015 =$ _____
8. $55 \div 0.11 =$ _____
9. $90 \times \frac{1}{300} \times \frac{20}{3} =$ _____
10. Write $5\frac{3}{4} \div 23$ as a fraction and as a decimal number. _____
11. Write $\frac{7}{100} \div \frac{3}{100}$ as a mixed number. _____
12. Write $\frac{\frac{4}{5}}{20}$ as a simple fraction in lowest terms. _____

The Diagnostic Test of Arithmetic helps students rediscover their understanding of basic math concepts and guides them in identifying areas for review.

Learn by Example. Each chapter unfolds basic concepts and skills through completely worked-out questions with solutions.

Example 10.16

Order: *For every 100 mL of urine output, replace with 40 mL of water via PEG tube q4h.* The client's urine output is 300 *mL*. What is the replacement volume?

Think of the problem as:

Output:	300 *mL* (out)	[single unit of measurement]
Replacement:	100 *mL* (out)/ 40 *mL* (in)	[equivalence]
Input:	? *mL* (in)	[single unit of measurement]

In this example, you want to change the single unit of measurement [*300 mL(out)*] to another single unit of measurement [*mL(in)*].

$$300\ mL(out) = ?\ mL(in)$$

The flow rate provides the equivalence [*100 mL(out)/40 mL(in)*] for the unit fraction.

$$300\ \cancel{mL(out)} \times \frac{40\ mL(in)}{100\ \cancel{mL(out)}} = 120\ mL(in)$$

So, the replacement volume is *120 mL*.

Example 6.12

Order: *levothyroxine sodium (Synthroid) 0.224 mg PO daily, one half hour before breakfast*. Read the label shown in Figure 6.14 and determine how many *tablets* of this synthetic thyroid hormone the client should receive. There are two strengths on the label (*mcg* and *mg*). It would be easier to do the problem using *milligrams* because the order is given in *milligrams*. However, for practice, the problem will be done here using the *microgram* strength.

Figure 6.14 Drug label for levothyroxine sodium (Synthroid).

Safe and Accurate Dosage Calculation

Safe and accurate dosage calculation comes from practice and critical thinking.

Try These for Practice, Exercises, and **Additional Exercises,** found in every chapter, test your comprehension of material.

Practice Sets

The answers to *Try These for Practice, Exercises*, and *Cumulative Review Exercises* are found in Appendix A. Ask your instructor for the answers to the *Additional Exercises*.

Try These for Practice

Test your comprehension after reading the chapter.

1. To do the exercises at the end of this chapter, you need to memorize all the equivalents presented so far. To test yourself, fill in the missing numbers in the following chart.

Metric System

(a) 1 *L* = _____ *mL*
(b) 1 *kg* = _____ *g*
(c) 1 *g* = _____ *mg*

Exercises

Reinforce your understanding in class or at home.

1. 20 *mL* ≈ = ? *t*
2. 50 *cm* ≈ ? *in*
3. 66 *lb* ≈ ? *kg*
4. 3 *pt* ≈ ? *mL*
5. 8 *in* ≈ ? *cm*
6. A baby weighs *5 lb 11 oz*. What is the baby's weight to the nearest whole *gram*?
7. How many grams of memantine are in the entire container whose label is shown in Figure 5.3?

Additional Exercises

Now, test yourself!

1. 4 *t* ≈ _____ *mL*
2. 8 *oz* ≈ _____ *mL*
3. 45 *mL* ≈ _____ *T*
4. 120 *mL* ≈ _____ *cup*
5. 150 *lb* ≈ _____ *kg* (round off to tenth of a *kg*)
6. Order: *albuterol sulfate 2 mg po t.i.d.* Read the label in Figure 5.6 and determine the number of teaspoons of syrup that are contained in one dose.

Cumulative Review Exercises begin in Chapter 4 and review mastery of earlier chapters.

Cumulative Review Exercises

Review your mastery of previous chapters.

1. Prescriber's order: *Administer Humulin R (regular insulin [rDNA origin]) subcutaneously as per the following blood-glucose results*:

For glucose less than 160 mg/dL	*—no insulin*
glucose 160 mg/dL–220 mg/dL	*—give 2 units*
glucose 221 mg/dL–280 mg/dL	*—give 4 units*
glucose 281 mg/dL–340 mg/dL	*—give 6 units*
glucose 341 mg/dL–400 mg/dL	*—give 8 units*
glucose greater than 400 mg/dL	*—notify MD stat*

How many units will you administer if the client's glucose level at lunchtime is
(a) *130 mg/dL*?
(b) *240 mg/dL*?
(c) *420 mg/dL*?

2. If *30 mg* of a drug is ordered *po daily* and the strength of the drug is *10 mg/mL*, how many *milliliters* will you administer?
3. If *30 mg* of a drug is ordered *po b.i.d.* and the strength of the drug is *10 mg/mL*, how many *milliliters* will you administer?

Case Studies. Clinical case scenarios provide opportunities for critical thinking as you apply concepts and techniques presented in the text.

Case Study 6.1

Read the case study and answer the questions. Answers can be found in Appendix A.

A 67-year-old female is admitted to the ambulatory surgery center for a repair of her fractured patella. An ORIF (open reduction external fixation) is planned. She has a history of heart failure, hypertension, hyperlipidemia, osteoarthritis, and Parkinson's dementia. She has a past surgical history of four caesarean sections and a cholecystectomy. She is 5 feet 7 inches tall and weighs 150 pounds. She denies any allergies to food or drugs, does not smoke, and drinks wine socially. Her vital signs on admission were: T 98.8° F; B/P 148/94; P 104 R 22. She received a regional block anesthesia, progressed well in the recovery room, and is preparing for discharge home.

Discharge orders

- Knee immobilizer, elevate leg, move toes as much as possible
- Ice to knee 20 *minutes* every hour
- Crutches, non-weight-bearing
- Observe for increased swelling or sudden severe pain
- Make appointment for follow-up care 2 weeks after discharge
- ondansetron HCl 4 *mg* PO q6h prn nausea
- oxycodone/acetaminophen (Percocet) 2.5/325 *mg* PO one or two tab q6h for pain. Take Percocet before becoming too uncomfortable.
- Resume pre-admission medications
  - diltiazem HCl (Cardizem LA) extended-release 180 *mg* PO daily
  - rivastigmine tartrate (Exelon) 3 *mg* PO B.I.D. with meals
  - valsartan (Diovan) 80 *mg* PO daily
  - atorvastatin (Lipitor) 20 *mg* PO daily
  - docusate sodium (Colace) 100 *mg* PO T.I.D.

1. Select the appropriate label and calculate how many tablets of diltiazem HCl the client will take each day.
2. Select the appropriate rivastigmine tartrate label and calculate how many capsules the client will take in 24 *hours*.

ALERT

The calibrations on the 1 *mL* syringe are very small and close together. Use caution when drawing up medication in this syringe.

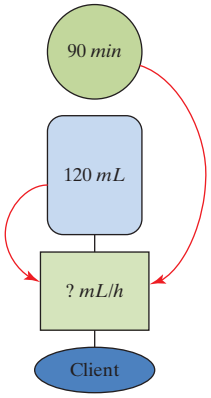
Notes and **Alerts** highlight concepts and principles for safe medication calculation and administration.

NOTE

The two rings on the stopper are called "top" ring and "bottom" ring because when the syringe is held with the needle facing upward, the "top" ring is above the "bottom" ring.

Realistic Illustrations. Real drug labels and realistic syringes aid in identifying and practicing with what you will encounter in actual clinical settings.

Figure 7.3 A sample of commonly used hypodermic syringes (35 *mL*, 12 *mL*, 5 *mL*, 3 *mL*, 1 *mL*, and 0.5 *mL*).



Schematic Diagrams To help students visualize some of the more difficult mathematical concepts involved in solutions and IVs.

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Contents

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Unit 1

Basic Calculation Skills and Introduction to Medication Administration

Chapter 1
Review of Arithmetic for Dosage Calculations

Learning Outcomes

After completing this chapter, you will be able to

1.1 Reduce and build fractions into equivalent forms.

1.2 Add, subtract, multiply, and divide fractions.

1.3 Simplify complex fractions.

1.4 Convert between decimal numbers and fractions.

1.5 Add, subtract, multiply, and divide decimal numbers.

1.6 Round decimal numbers to a desired number of decimal places.

1.7 Write percentages as equivalent decimal numbers and fractions.

1.8 Find the percent of a number and the percent of change.

1.9 Estimate answers.

1.10 Use a calculator to verify answers.

Medical dosage calculations can involve whole numbers, fractions, decimal numbers, and percentages. Your results on the *Diagnostic Test of Arithmetic*, found on the next page, will identify your areas of strength and weakness. You can use this chapter to improve your math skills or simply to review the kinds of calculations you will encounter in this textbook.

Name: _____ Date: _____

Diagnostic Test of Arithmetic

The following Diagnostic Test illustrates *all* the arithmetic skills needed to do the computations in this textbook. Take the test and compare your answers with the answers found in Appendix A. If you discover areas of weakness, carefully review the relevant review materials in this chapter so that you will be mathematically prepared for the rest of the textbook.

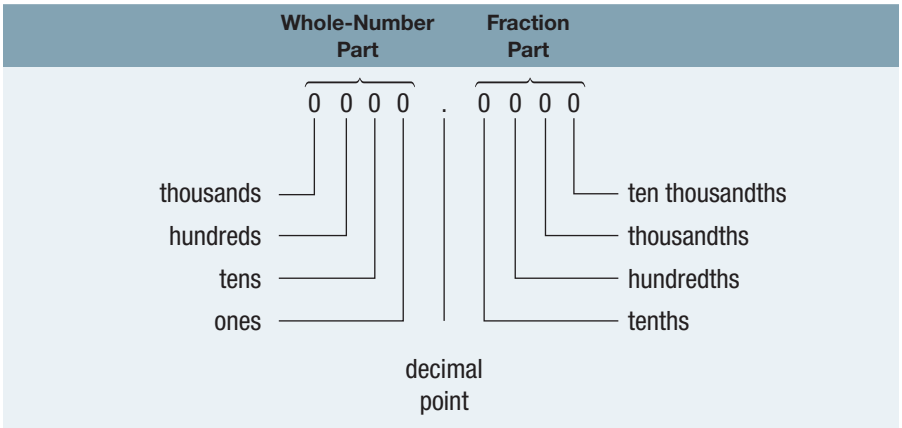
1. Write 0.375 as a fraction in lowest terms.
2. Write $\frac{28{,}500}{100{,}000}$ as a decimal number.
3. Round off 6.492 to the nearest tenth.
4. Write $\frac{5}{6}$ as a decimal number rounded off to the nearest hundredth.
5. Simplify $\frac{0.63}{0.2}$ to a decimal number rounded off to the nearest tenth.
6. $0.038 \times 100 =$
7. $4.26 \times 0.015 =$
8. $55 \div 0.11 =$
9. $90 \times \frac{1}{300} \times \frac{20}{3} =$
10. Write $5\frac{3}{4} \div 23$ as a fraction and as a decimal number.
11. Write $\frac{7}{100} \div \frac{3}{100}$ as a mixed number.
12. Write $\frac{\frac{4}{5}}{20}$ as a simple fraction in lowest terms.
13. Write 45% as a fraction in lowest terms.
14. Write 0.025 as a percent.
15. Write $2\frac{4}{7}$ as an improper fraction.
16. 30% of 40 =
17. $4.1 + 0.5 + 3 =$
18. $\frac{1}{4} + \frac{3}{8} =$ *(express in fractional form)*
19. The price of a suit increased from \$80 to \$100. What was the percent of increase in the price of the suit?
20. Express the ratio of *15 to 20* as a percent.

Decimal Numbers and Fractions

Changing Decimal Numbers to Fractional Form

A decimal number represents a fraction with a denominator of 10; 100; 1,000; and so on. Each decimal number has three parts: the whole-number part, the decimal point, and the fraction part. For example, the decimal number 2.7 is equivalent to the mixed number $2\frac{7}{10}$, and both are read as *two and seven tenths*. Table 1.1 shows the names of the decimal positions (place values).

Table 1.1 Names of Decimal Positions.



Reading a decimal number will help you write it as a fraction.

Decimal Number	⟶	Read	⟶	Fraction
4.1	⟶	four and one tenth	⟶	$4\frac{1}{10}$
0.3	⟶	three tenths	⟶	$\frac{3}{10}$
6.07	⟶	six and seven hundredths	⟶	$6\frac{7}{100}$
0.231	⟶	two hundred thirty-one thousandths	⟶	$\frac{231}{1,000}$
0.0025	⟶	twenty-five ten thousandths	⟶	$\frac{25}{10,000}$

NOTE

A decimal number that is less than 1 is written with a leading zero—for example, 0.3 and 0.0025 (not .3 and .0025).

A number can be written in different forms. A decimal number *less than 1*, such as 0.9, is read as *nine tenths* and also can be written as the *proper fraction* $\frac{9}{10}$. In a **proper fraction,** the **numerator** (the number on the top) of the fraction is smaller than its **denominator** (the number on the bottom).

Mixed Numbers and Improper Fractions

A decimal number *greater than 1*, such as 3.5, is read as *three and five tenths* and can also be written as the *mixed number* $3\frac{5}{10}$ or reduced to lowest terms as $3\frac{1}{2}$. A **mixed number** combines a whole number and a proper fraction. The *mixed number* $3\frac{1}{2}$ can be changed to an *improper fraction* as follows:

$$3\frac{1}{2} = \frac{3 \times 2 + 1}{2} = \frac{7}{2}$$

The numerator of an **improper fraction** is larger than or equal to its denominator.

Any number can be written as a fraction by writing it over 1. For example, 9 can be written as the improper fraction $\frac{9}{1}$.

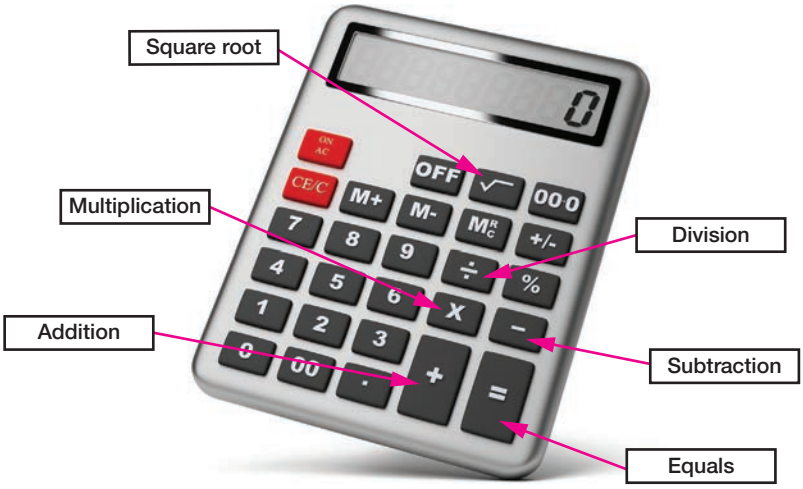
Calculator

To help avoid medication errors, many healthcare agencies have policies requiring that calculations done by hand be verified with a calculator. "Drop-down" calculators are available on the computer screen to candidates who are taking the National Council Licensure Examination for Registered Nurses (NCLEX-RN) or the National Council Licensure Examination for Practical Nurses (NCLEX-PN). Therefore, it is important to know how to use a calculator.

A basic four-function (addition, subtraction, multiplication, and division), handheld calculator with a square-root key $\sqrt{\ }$ is sufficient to perform most medical dosage calculations. See Figure 1.1.

Figure 1.1 Basic handheld calculator similar to the drop-down calculator on the NCLEX examination.

SOURCE: Anatoly Maslennikov/123RF



To change the improper fraction $\frac{7}{2}$ to a decimal number with a calculator:

First press 7
Then press ÷
Then press 2
Then press =
The display shows 3.5

This keystroke sequence will be abbreviated as 7 ÷ 2 = 3.5

Throughout this chapter, keystroke sequences are shown for selected examples. The calculator icon, , indicates where this occurs.

NOTE

Some calculators use the Enter key rather than the = key.

NOTE

The keystroke sequences presented in this chapter apply to NCLEX-type drop-down calculators. But not all calculators work the same way. If you have a problem, consult the user's manual for your calculator.

Example 1.1

Write 2.25 as a mixed number and as an improper fraction.

The number 2.25 is read *two and twenty-five hundredths* and is written $2\frac{25}{100}$. You can simplify:

$$2\frac{25}{100} = 2\frac{\overset{1}{\cancel{25}}}{\underset{4}{\cancel{100}}} = 2\frac{1}{4} = \frac{2 \times 4 + 1}{4} = \frac{9}{4}$$

So, 2.25 can be written as the mixed number $2\frac{1}{4}$ or as the improper fraction $\frac{9}{4}$

Keystroke Sequence for Example 1.1:

To verify that $2\frac{25}{100}$ and $\frac{9}{4}$ both equal 2.25, enter the following keystroke sequences.

9 ÷ 4 = 2.25

2 + 25 ÷ 100 = 2.25

Ratios

A **ratio** is a comparison of two numbers.

The ratio of *5 to 10* can also be written as *5:10* or in fractional form as $\frac{5}{10}$. This fraction may be *reduced by cancelling* by a number that evenly divides both the numerator and the denominator. Because *5* evenly divides both *5* and 10, divide as follows:

$$\frac{5}{10} = \frac{5 \div 5}{10 \div 5} = \frac{1}{2}$$

The fraction $\frac{5}{10}$ is *reduced to lowest terms* as $\frac{1}{2}$.

So, the ratio of *5 to 10* can also be written as the ratio of *1 to 2* or *1:2*

Keystroke Sequence for Example 1.2:

To verify that $\frac{6}{18}$ equals $\frac{1}{3}$, use these two keystroke sequences,

6 ÷ 18 = 0.333...

1 ÷ 3 = 0.333...

Example 1.2

Express 6:18 as an equivalent fraction and ratio in lowest terms.

The ratio *6:18*, also written as *6 to 18*, can be written in fractional form as $\frac{6}{18}$. This fraction may be *reduced by cancelling* by a number that evenly divides both the numerator and the denominator. Because 6 divides both 6 and 18, divide as follows:

$$\frac{6}{18} = \frac{6 \div 6}{18 \div 6} = \frac{1}{3}$$

So, the ratio 6 to 18 equals the fraction $\frac{1}{3}$ and the ratio 1:3

Keystroke Sequence for Example 1.3:

To verify that $\frac{1}{10}$ equals $\frac{12}{120}$, use

1 ÷ 10 = 0.1

12 ÷ 120 = 0.1

Example 1.3

Write the ratio 1:10 as an equivalent fraction with 120 in the denominator.

Because 1:10 as a fraction is $\frac{1}{10}$, you need to write this fraction with the larger denominator of 120. Such processes are called **building fractions.**

$$\frac{1}{10} = \frac{?}{120}$$

$\frac{1}{10}$ may be built up by *multiplying the numerator and denominator of the fraction by the same number* (12 in this case) as follows:

$$\frac{1}{10} = \frac{1 \times 12}{10 \times 12} = \frac{12}{120}$$

So, 1:10 is equivalent to $\frac{12}{120}$

NOTE

When *reducing* a fraction, you *divide* both numerator and denominator by the same number. This process is called *cancelling*.

When *building* a fraction, you *multiply* both numerator and denominator by the same number.

Changing Fractions to Decimal Numbers

To change a fraction to a decimal number, think of the fraction as a division problem. For example:

$$\frac{2}{5} \quad \text{means} \quad 2 \div 5 \quad \text{or} \quad 5\overline{)2}$$

Here are the steps for this division.

Step 1 Replace 2 with 2.0, and then place a decimal point directly above the decimal point in 2.0.

$$5\overline{)2.0}$$

Step 2 Perform the division *twenty divided by five = four*.

$$\begin{array}{r} 0.4 \\ 5\overline{)2.0} \\ \underline{2\,0} \\ 0 \end{array}$$

So, $\frac{2}{5} = 0.4$

Keystroke sequence:

2 ÷ 5 = 0.4

Example 1.4

Write $\frac{5}{2}$ as a decimal number.

$$\frac{5}{2} \quad \text{means} \quad 5 \div 2 \quad \text{or} \quad 2\overline{)5}$$

Step 1 $2\overline{)5.0}$

Step 2

$$\begin{array}{r} 2.5 \\ 2\overline{)5.0} \\ \underline{4} \\ 10 \\ \underline{10} \\ 0 \end{array}$$

So, $\frac{5}{2} = 2.5$

Keystroke Sequence for Example 1.4:

5 ÷ 2 = 2.5

Example 1.5

Write $\frac{193}{10}$ as a decimal number.

$\frac{193}{10}$ means $193 \div 10$ or $10\overline{)193}$

Step 1 $10\overline{)193.0}$

Step 2
$$\begin{array}{r} 19.3 \\ 10\overline{)193.0} \\ \underline{10} \\ 93 \\ \underline{90} \\ 30 \\ \underline{30} \\ 0 \end{array}$$

So, $\frac{193}{10} = 19.3$

Keystroke Sequence for Example 1.5:

193 ÷ 10 = 19.3

Dividing Decimal Numbers by Powers of 10

The numbers 10; 100; 1,000; 10,000… are called powers of ten. Dividing decimal numbers by powers of ten can be accomplished by merely moving the decimal point in the decimal number to the left. The number of places to move the decimal point is equal to the number of zeros in the power of ten.

There is a quicker way to do Example 1.5. To divide a *decimal number by 10, move* the decimal point in the number *one place to the left*. Notice that there is one zero in 10.

$$\frac{193}{10} = \frac{193.}{10} = 193.\ = 19.3$$

To *divide a number by 100, move* the decimal point in the number *two places to the left* because there are two zeros in 100. So, the quick way to divide by 10; 100; 1,000; and so on is to count the zeros and then move the decimal point to the left the same number of places; the answer should always be a *smaller* number than the original number. Check your answer to be sure.

Example 1.6

Write $\frac{9.25}{100}$ as a decimal number.

This fraction means $9.25 \div 100$. There are two zeros in 100, so move the decimal point in 9.25 two places to the left, and fill the empty position with a placeholding zero.

$$\frac{9.25}{100} = 9.25 = 0.0925$$

Keystroke Sequence for Example 1.6:

9.25 ÷ 100 = 0.0925

Rounding Decimal Numbers

Sometimes it is convenient to round an answer—that is, to use an approximate answer rather than an exact one.

Rounding Off

To round off 1.267 to the *nearest tenth*—that is, to round off the number to *one decimal place*—do the following:

> *Look at the digit after the tenths place (the hundredths-place digit). Because this digit (6) is 5 or more, round off 1.267 by adding 1 to the tenths-place digit. Finally, drop all the digits after the tenths place.*
>
> *So, 1.267 is approximated by 1.3 when rounded off to the nearest tenth.*

To round off 0.8345 to the *nearest hundredth*—that is, to round off the number to *two decimal places*—do the following:

> *Look at the digit after the hundredths place (the thousandths-place digit). Because this digit (4) is less than 5, round off 0.8345 by leaving the hundredths digit alone. Finally, drop all the digits after the hundredths place.*
>
> *So, 0.8345 is approximated by 0.83 when rounded off to the nearest hundredth.*

Example 1.7

Round off 4.8075 to the nearest hundredth, tenth, and whole number.

4.8075 rounded off to the nearest: hundredth → 4.81

tenth → 4.8

whole number → 5

Rounding Down and Rounding Up

In the *rounding off* process, either 0 or 1 is added to the appropriate digit of a given number; therefore, the rounded result can be either smaller or larger than the given number. In healthcare, two other types of rounding are also used. **Rounding down** and **rounding up** are similar to rounding **off**. The only difference is that in *rounding down, 0 is always added* to the appropriate digit, whereas in *rounding up, 1 is always added* to the appropriate digit.

When rounding down both 2.34 and 2.36 to the tenths place, *add 0* to the tenths-place digit and delete the remaining digits. Thus, both 2.34 and 2.36 round down to 2.3.

When rounding up 2.34 and 2.36 to the tenths place, *add 1* to the tenths-place digit and delete the remaining digits. Thus, both 2.34 and 2.36 round up to 2.4.

Generally speaking, rounding down results in a smaller quantity, whereas rounding up results in a larger quantity. So, *rounding down* a dosage helps to avoid an overdose, and *rounding up* a dosage helps to avoid an underdose. When rounding a dosage calculation, most of the time rounding off is used. However, sometimes rounding down is used, whereas rounding up is very rarely used.

NOTE

Rounding down is also referred to as *truncating*, which means "cutting off" digits.